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[1] Date of issue—December 1953.
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By an unfortunate error the photographs in figures 1 and 3, pp. 235 and 238, respectively, vol. XXXVII, No. 3, 1953, were transposed. In this article on Control of the Laurel Thrips by George N. Wolcott figure 3 on pg. 238 should be figure 1 on page 235, and figure 1 should be figure 3. The legends are correct, the photographs reversed.

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LEAVING SUGARCANE TRASH UNDISTURBED ON A LATERIC SOIL COMPARES FAVORABLY WITH CURRENTLY USED TRASH-DISPOSAL METHODS

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INTRODUCTION

In a previous paper Landrau and Samuels (1)[2] reported that yields of sugarcane in a Vega Alta silty clay at Río Piedras were increased significantly for 2 years after the fourth-ratoon crop as a result of aligning the trash instead of burning or burying it. Lugo-López, et al. (2), further reported on the effect of the various trash-disposal or trash-handling procedures upon the physical and chemical properties of the soil at the same location. Soil organic matter was found to be significantly lower in the burned-trash plots than in the aligned- and in the buried-trash plots. Furthermore, permeability and infiltration appeared to be slower in the burned-trash plots.

Landrau and Samuels (1) reported no differences in sugarcane yields attributable to treatments in four crops of a second trash-disposal experiment under way at Isabela. This paper reports on the soil conditions at the experimental field at Isabela where treatment differentials had been established for the 5 years, 1947–52. Furthermore, yield data reported previously (1) are brought up to date to include the past two cropping seasons.

MATERIALS AND METHODS

Soil Description

The trash-handling or trash-disposal experimental field at Isabela was established in 1946 at the Substation Farm in an area of Coto clay, a yellowish-brown lateritic soil derived from limestone. This soil is rather ex-

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Appreciation is expressed to A. Riollano for his aid in supervising all field operations. R. Gandía and R. Abrahms helped in sampling and conducting the infiltration tests.

[2] Numbers in parentheses refer to Literature Cited, p. 8.

tensive throughout the northwest coastal plains. A profile to a depth of 42 inches examined on March 2, 1951, revealed a medium-brown clayey surface soil about 8 inches in depth with medium-size fragmental to rounded structural aggregates. The 8- to 18-inch transitional layer had well-defined fragments with a tendency to be cubical. A gradual color change from brown to light yellow was observed in going into the deeper layers. Porosity was highly visible down to 42 inches. Underlying this layer was the limestone parent rock. Coto clay is a soil with good physical conditions for crop growth, but of moderately low fertility.

Field Work

The procedures for the handling of the trash in each treatment were as follows:

(1) *Trash aligned:* The trash was aligned in alternate banks.

(2) *Trash aligned and furrowed:* The trash was aligned in alternate banks and a shallow furrow was opened on the clean banks.

(3) *Undisturbed trash:* The trash in the plot was left lying on the field after harvesting and removing the cane.

(4) *Trash burned:* The trash was spread evenly over the plot and then burned.

The treatments were repeated every year after harvest. Each treatment was replicated nine times. The plots were 150 feet long by 20 feet wide and the cane rows were 4 feet apart. The plots were arranged following a simple randomized-block layout.

The variety of cane used was P.R. 905, which has proved to be one of the superior varieties for the area. Three crops were harvested from the original planting, and a new planting was made in the spring of 1949. The field as a whole received a yearly application of 1,200 pounds to the acre of a 15–3–10 fertilizer. After the second ratoon of the new crop cycle was harvested, infiltration tests were run in the field and soil samples were taken from each plot for laboratory analyses.

Bulk samples were taken from the upper 6 inches of soil. Each composite sample consisted of 10 units. Undisturbed core samples, 3 inches in diameter and 3 inches in length, were also taken at a 1- to 4-inch depth by using a Bradfield soil sampler. The buffer-compartment method was used to determine the infiltration rate. In this method iron rings 9, 18, and 27 inches in diameter are jacked into the soil. A ¼-inch head of water is maintained in the center ring by means of a self-dispensing 2,000-cc. burette. The same hydraulic head is maintained in the outer compartments to minimize lateral movements of water from the inner ring where measurements are taken hourly. The tests are run for eight consecutive hours.

Analytical Work

Permeability measurements were made in undisturbed soil cores by recording the rate at which water moved through a saturated column of soil at a known hydraulic head. Quick drainage was determined by placing the saturated core in a Buchner funnel, setting a 60-cm. tension and measuring the water drained after a 15-minute period. The water retained at pF 1.78 was measured by bringing the soil core to equilibrium with a 60-cm. tension and determining the variation in weight of the core. The maximum saturation was calculated from the above data.

The soil core was finally dried in the oven at 110°C. As the sampler used had a definite known volume, the bulk density of the soil was calculated by dividing the net dry weight by its volume. The pore space was then calculated by assuming a specific gravity for the soil particles of 2.65. The term "air porosity", as used in this paper, refers to the difference between the theoretical pore space and the water porosity as indicated by the volume of water retained at pF 1.78. Water retained at pF 2.7 and pF 4.2 was determined by submitting saturated soil samples in special plates to pressures of 0.5 and 15 atmospheres, respectively. The available water was considered as the difference in water retention between pF 1.78 and pF 4.2.

The pH was determined electrometrically using a Macbeth pH-meter. Total nitrogen was determined by the standard Kjeldahl method and the organic matter by the chromic acid titration method. The carbon-nitrogen ratio was subsequently calculated from the above data.

RESULTS AND DISCUSSION

Yields

Yield data for the first crop cycle and two crops of the second one are presented in table 1. The treatment differentials were established after the first plant cane crop was harvested. The plots for this plant crop were all treated uniformly and no significant cane-yield differences were observed. No significant differences due to treatments could be measured in the following five crops. The undisturbed-trash treatment, which had the lowest labor requirements, gave yields which compared favorably with those from the other treatments the labor costs of which were higher. In areas where drainage is not a limiting factor, it may prove to be economically advantageous to leave the trash undisturbed on the surface of the soil. Cultivation costs, particularly weeding, could thus also be decreased. In addition, direct evaporation losses from the soil could be reduced by the trash mulch on its surface. Vicente-Chandler (4) reduced soil-moisture losses by evaporation over 50 percent by mulching with sugarcane trash

TABLE 1.—*Mean yields of sugarcane for 6 crops at the Isabela experimental field, as affected by the trash-disposal method used*

Treatment of trash	Mean yield of cane for the plant cane, 1946–47	Mean yield of 96° sugar for indicated crop				
		First ratoon, 1947–48	Second ratoon, 1948–49	New planting, 1949–50	First ratoon, 1950–51	Second ratoon, 1951–52
	Cwt./acre	*Cwt./acre*	*Cwt./acre*	*Cwt./acre*	*Cwt./acre*	*Cwt./acre*
Aligned	803	98	83	101	80	92
Aligned and clean banks furrowed	793	94	75	101	74	90
Undisturbed	818	104	82	98	74	86
Burned	762	96	70	107	72	91
L.S.D. at the 5-percent level	97	13	30	12	10	11
L.S.D. at the 1-percent level	132	18	41	17	13	15

under the conditions that prevail at Aguirre, in southern Puerto Rico. Furthermore, the mulched soil was cooler in the plow layer and evidence was obtained showing that mulching reduced the rather large variations in soil temperature likely to occur in bare surface soil throughout the day.

Soil Properties

The results of the chemical analyses of the soils taken from the Isabela trash-handling experimental field are shown in table 2. The general pH values ranged from 4.7 to 6.0 with a mean value of 5.2 for the whole field, disregarding treatments. There were no significant differences between the means of the treatments. The mean nitrogen content of the soils under all treatments combined was 0.183 percent. There were no significant differences between the mean nitrogen content of the soils from the experi-

TABLE 2.—*Mean pH, nitrogen, organic-matter content, and C/N ratio of soils from the experimental field at Isabela, as affected by the trash-disposal method used*

Treatment of trash	pH	Nitrogen	Organic matter	C/N ratio
		Percent	*Percent*	
Aligned	5.18	0.188	2.71	8.6
Aligned and clean banks furrowed	5.22	.181	2.51	8.1
Undisturbed	5.14	.183	3.54	8.1
Burned	5.28	.183	2.66	8.4
L.S.D. at the 5-percent level	0.19	0.009	0.30	0.97
L.S.D. at the 1-percent level	.26	.013	.41	1.31

TABLE 3.—*Rate of infiltration of soils where sugarcane trash was aligned, aligned and furrowed, left undisturbed, or burned for 5 consecutive years, Isabela experimental trash-disposal field*

Treatment of trash	Infiltration rate in inches of water per hour at hour indicated							
	1st	2d	3d	4th	5th	6th	7th	8th
Aligned	4.75	2.88	2.87	2.57	2.36	2.93	2.26	2.70
Aligned and clean banks furrowed	2.97	1.87	1.79	1.74	2.19	1.99	1.93	1.80
Undisturbed trash	2.77	1.70	1.55	1.56	1.54	1.69	1.43	1.39
Burned	3.11	1.50	1.31	1.44	1.52	1.13	1.10	1.10
L.S.D. at the 5-percent level for the eighth hour								0.53
L.S.D. at the 1-percent level for the eighth hour								.72

mental plots, whether the trash was aligned, aligned and the clean bank furrowed, undisturbed, or burned.

No significant differences were observed in the soil organic-matter content of the plots where the trash was differently handled for 5 years. Difficulties were encountered in sampling for organic-matter determinations in the four treatments. Although all surface trash was removed before sampling, there was considerable variation in the organic-matter content of soil samples taken within a given plot. The plots where the trash was burned yearly have received considerably less organic materials than those where it was handled otherwise, but the organic-matter content after 5 years remained more or less the same. The mean C/N ratios were narrow for all treatments. They further indicated that the carbonaceous materials decomposed quickly.

Table 3 gives the mean infiltration rate of the soil determined for each of 8 hours on plots where the trash was differently handled for the past 5 years. In general, the soil-infiltration rate was faster in the plots where the trash was aligned than in those where it was otherwise handled. The differences between the means of the treatments were significant. In all cases, however, the rate of infiltration at the eighth hour was from moderate to moderately rapid. In an area where supplemental irrigation is necessary as in Isabela, a moderately rapid rate of infiltration may be a handicap. In this connection, the value of leaving the trash untouched over the surface soil may be of tremendous importance, insofar as it reduces the water losses by direct evaporation.

The results of the permeability tests and other soil-moisture measurements performed are reported on table 4. In general, there were no significant differences in the moisture characteristics of the soils undergoing the various trash-disposal treatments. The lack of significant differences in

TABLE 4.—*Permeability and other soil-moisture data gathered from 1- to 4-inch-depth soil cores collected at the experimental field at Isabela, as affected by the trash-disposal method used*

Treatment of trash	Permeability	Water drained at 60 cm. in 15 minutes	Maximum saturation	Water retained at pF—			Available water (water retained at pF 1.78 minus water retained at pF 4.2)
				1.78	2.7	4.2	
	In./hr.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Aligned	18.37	11.27	55.75	39.10	30.78	23.78	15.32
Aligned and clean banks furrowed	10.40	9.90	54.22	41.02	30.12	23.60	17.42
Undisturbed	16.69	8.20	53.20	40.42	31.88	26.28	14.15
Burned	—	12.22	54.95	40.32	31.52	23.28	17.05
L.S.D. at the 5-percent level	39.23	5.16	3.02	4.93	3.47	2.87	3.98
L.S.D. at the 1-percent level	59.44	7.42	4.34	7.08	4.99	4.13	5.73

regard to these physical properties of the soil are in line with the lack of differences in the organic-matter level of the soils, in spite of the differences in methods of trash handling used. In a previous report (3) from a somewhat similar experiment at Río Piedras, where different organic-matter levels resulted from various trash-handling procedures, observations were made indicating that permeability and water retention at low tensions were higher with higher organic-matter accumulations.

Table 5 presents data on bulk density, total porosity, and air porosity of soils taken from the variously treated plots. The bulk-density values range from mean values of 1.13 gm./cc. for the soil from the plots where the trash was burned to 1.21 for the soil where the trash was undisturbed. The

TABLE 5.—*Bulk density, pore space, and air capacity of soils from the sugarcane experimental field at Isabela, as affected by the trash-disposal method used*

Treatment of trash	Bulk density	Pore space	Air porosity (pore space-volume of water retained at pF 1.78)
	Gm./c.c.	*Percent*	*Percent*
Aligned	1.15	56.50	17.40
Aligned and clean banks furrowed	1.18	54.45	13.50
Undisturbed	1.21	54.22	13.80
Burned	1.13	57.50	17.18
L.S.D. at the 5-percent level	0.11	3.77	7.03
L.S.D. at the 1-percent level	.16	5.41	10.09

mean porosity value for the soil from all plots considered together was 55.69 percent by volume with deviations of only 1.81 and 1.47 above and below. The air porosity was higher from plots where the trash was burned and aligned, and lower from those where it was aligned and plowed and left undisturbed over the surface. The differences, however, were not significant.

SUMMARY AND CONCLUSIONS

The production of sugar was not influenced by the various methods of handling sugarcane trash (aligning, aligning and furrowing, leaving undisturbed, or burning) on a field of Coto clay, a highly permeable lateritic soil at Isabela in northwestern Puerto Rico. No significant differences due to treatments were observed in organic-matter or nitrogen content, pH, C/N ration, permeability, quick drainage, water retained at various tensions, bulk density, or porosity, determined from soil samples taken after harvesting the sixth crop. The minimum infiltration capacity of the soils from the plots where the trash was burned or undisturbed was moderate, while that of the soils where the trash was aligned, or aligned and the clean banks furrowed, was moderately rapid.

The yields from plots where the trash was left undisturbed over the surface were as high as those where it was either burned, aligned, or aligned and the clean banks furrowed. Trash disposal is generally expensive. By leaving the trash undisturbed, cultivation costs can be reduced considerably. Weeds are usually smothered under the trash. In areas where drainage problems are not very acute, it may prove economically advantageous in the long run to follow this practice. Furthermore, direct moisture-evaporation losses from the soil will probably be reduced by mulching the whole surface soil.

RESUMEN Y CONCLUSIONES

El método de disponer de la paja después de la cosecha de la caña de azúcar no afectó la producción en un campo experimental ubicado en Isabela, en la zona noroeste de Puerto Rico. El suelo del campo era del tipo arcilla Coto, laterítico y muy permeable. Los tratamientos con la paja fueron:

1. Alineada a lo largo del banco roturado
2. Alineada a lo largo del banco sin roturar
3. Dejada en su sitio después del corte
4. Quemada.

No se registraron diferencias significativas debido al efecto de los tratamientos sobre permeabilidad, desagüe rápido, humedad retenida a varias tensiones, densidad aparente y porosidad en las muestras de suelos tomadas después de cosechar el segundo retoño del segundo ciclo. La infiltración

mínima fué moderada en las parcelas donde se quemó la paja y donde ésta no se movió; en aquéllas donde la paja se alineó y en donde la paja se alineó y roturó el banco, la infiltración fué moderadamente rápida.

Los rendimientos de las parcelas donde la paja de caña se dejó sin mover sobre la superficie fueron tan altos como los de aquéllas en las que se quemó, se alineó, y se alineó y roturó el banco. La manipulación de la paja generalmente resulta costosa. Dejándola sin mover se pueden reducir bastante los costos de cultivo. El número de desyerbos también resulta menor. En zonas donde no haya problemas graves de desagüe puede resultar, a larga, económicamente ventajosa la práctica de dejar la paja sobre la superficie sin mover. Además, las pérdidas de humedad por evaporación directa del suelo, podrían reducirse efectivamente cuando se deja la paja sobre el campo.

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SEROLOGICAL REACTIVITY OF SUGARCANE-MOSAIC VIRUS

J. Enrique Pérez and José Adsuar[1]

INTRODUCTION

Sugarcane mosaic is a widespread disease occuring in many parts of the world. It is a disease of economic importance and has been reported several times in Puerto Rico (1, 2, 3, 4)[2]. Using the precipitin test, Chester (5) reported negative findings on the serological activity of the virus causing this disease. However, in 1935, Desai (6) reported on the antigenic properties of sugarcane-mosaic virus. Since his report, investigations on the serological properties of the virus seem to have remained at a standstill. It thus appeared desirable to reopen the investigation of sugarcane mosaic along these lines with the idea of preparing antisera for use in field surveys of this disease.

Moreover, Summers, Brandes, and Rands (7) had demonstrated the existence of several strains of sugarcane-mosaic virus by the inoculation of differential hosts. Bruehl (8) recently obtained evidence of the existence of several strains of the virus in Puerto Rico. The possibility of studying the relationship between the various strains by means of serological tests (9) therefore remained open.

The present paper is a preliminary report on the serological activity of sugarcane-mosaic virus.

MATERIALS AND METHODS

Preparation of Virus (Antigen) for Inoculation

The sugarcane-mosaic virus was propagated in sugarcane variety B.H. 10–12 grown in the Station grounds. Cane juice was expressed by grinding in a meat chopper at 7°C. The juice was then centrifuged at about 3,800 r.p.m. in a refrigerated International PR-1 centrifuge for 20 minutes. The sediment was discarded and the supernatant liquid was again centrifuged at about 19,000 r.p.m. (25,000 g)[3] for 2 hours using a "multispeed attachment." The sediment thus obtained was resuspended in 0.01-molar phosphate buffer at pH 7.0, using $\frac{1}{10}$ of the original volume of juice. After suspension in the buffer a homogeneous light-green liquid was obtained. This material was then subjected to a second low-speed cycle and,

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[2] Numbers in parentheses refer to Literature Cited, pp. 14–5.

[3] Gravitational force in kilograms per gram.

although a slight dark-green sediment was obtained, the supernatant liquid retained a green opalescent color. This supernatant liquid was then distributed in small vials and kept at −15°C. until used for inoculation or other tests. This is referred to as "concentrate" below. All centrifuging was carried out at temperatures of 4° to 8°C.

INFECTIVE CONTROLS

Qualitative tests for the presence of virus in (1) the expressed juice, (2) the supernatant liquid after high-speed centrifuging, and (3) the concentrate were carried out by rubbing leaves of sorghum, *Holcus sorghum*, using the carborundum method. Ten to twenty plants were used for each control. All controls were positive for virus as shown by the development of characteristic symptoms in the majority of plants from 7 to 12 days after inoculation.

PREPARATION OF ANTISERUM

Young healthy rabbits weighing about 6 pounds each were used in preparing the antiserum. Normal serum was obtained from each rabbit before inoculation. Each animal was then injected once a week with varying amounts of antigen by both the intraperitoneal and intravenous routes. Serum was obtained from the rabbits 1 week after the second inoculation and tested for antibody by the precipitation technique described below. A second series of two injections per week was then given for 2 weeks and the serum retested. The rabbits were then exsanguinated under aseptic conditions and the serum was placed in vaccine bottles and refrigerated until used. The precipitation test described below was used solely for determining the antibody response.

Precipitation Test

PREPARATION OF ANTIGEN

Healthy cane juice from variety B.H. 10–12 plants, as well as infective juice from mosaic-diseased plants of the same lot used for preparing the antigen for inoculation, was expressed as described before and centrifuged at 3,000 r.p.m. for 30 minutes. The supernatant liquids were placed in the icebox overnight. Next day the juices were centrifuged in a Servall SS-2 angle centrifuge at 6,000 r.p.m. (6,000 g) for 15 minutes for final clarification. The antigen prepared by high-speed centrifugation was also used in testing the sera for antibodies, the sera reacting to the same titer as with the fresh antigen.

ABSORPTION OF SERUM

After the healthy cane juice had been centrifuged at 3,000 r.p.m. for 30 minutes it was mixed with antiserum in the proportion of 3 parts of juice

to 1 part of serum and incubated at 37°C. for 2 hours. The serum-juice mixture was then removed from the incubator and placed in the icebox overnight. Next day any precipitate formed was thrown down by centrifuging at 2,000 r.p.m. for 20 minutes. The absorbed sera were then ready for use.

TITRATION OF ANTISERUM

The absorbed serum was diluted in buffered saline of pH 7 in twofold steps in 75 × 10 mm. test tubes. An equal volume of antigen (infective cane juice) was added to each tube. Dilutions were made in duplicate and after shaking the mixtures, one set of dilutions was placed in a 37°C. incubator and another in a 40°C. water bath. All tubes were examined for the presence of precipitate at intervals of 15, 30, 45, 60, and 120 minutes after the start of the incubation period. The mixtures were then removed from the bath and incubator and placed in the icebox at 8° to 10°C. overnight. Next day the reaction was read again after the tubes reached room temperature.

For reading, the tubes were placed in such a way as to receive oblique illumination from a fluorescent lamp. Titers were read as the final serum dilution where definite and easily perceptible precipitation was observed. The occurrence of nonspecific reactions was controlled by subjecting the following mixtures to the same incubation periods and conditions: (1) Healthy cane juice plus saline, (2) healthy cane juice plus antiserum, (3) infective cane juice plus saline, and (4) infective cane juice plus normal rabbit serum. In these controls sera and juices were mixed in the stronger concentrations used in the actual titration.

RESULTS

Results from a representative experiment of duplicate tests carried out both at 37°C. and 40°C. and read before and after placing in the cold are shown in table 1. Three different experiments gave essentially the same results.

From table 1 it can be seen that incubation in a 40°C. water bath hastened precipitation. At 37°C. both sera reacted to a titer of $\frac{1}{16}$ when read after 60 minutes while at 40°C. both sera reacted to a titer of $\frac{1}{32}$. The reaction was also more intense at 40°C. during the first interval. However, at the end of the incubation period (2 hours) the sera reacted to the same titers whether incubated at 37°C. or 40°C., and the reaction was of comparable intensity. A definite two- to fourfold rise in titer was observed with both sera after they were placed in the cold. Final titer obtained were $\frac{1}{128}$ for rabbit No. 1 serum and $\frac{1}{256}$ for rabbit No. 2 serum.

The above data confirm the fact that sugarcane-mosaic virus is antigenic

TABLE 1.—*Data on titration of antisera to sugarcane-mosaic virus*

Temperature	Sera from—	Incubation period	Reaction[1] of final serum dilution indicated—						
			1/8	1/16	1/32	1/64	1/128	1/256	1/512
Test runs									
37° C.	Rabbit No. 1	30 min.	−	−	−	−	−	−	−
		60 min.	+	+	−	−	−	−	−
		90 min.	+	+	+	−	−	−	−
		120 min.	+	+	+	+	+	−	−
		19 hr.[2]	+	+	+	+	+	−	−
	Rabbit No. 2	30 min.	−	−	−	−	−	−	−
		60 min.	+	+	−	−	−	−	−
		90 min.	+	+	+	+	−	−	−
		120 min.	+	+	+	+	−	−	−
		19 hr.[2]	+	+	+	+	+	+	−
40° C.[3]	Rabbit No. 1	30 min.	−	−	−	−	−	−	−
		60 min.	+	+	+	−	−	−	−
		90 min.	+	+	+	−	−	−	−
		120 min.	+	+	+	+	−	−	−
		19 hr.[2]	+	+	+	+	+	−	−
	Rabbit No. 2	30 min.	−	−	−	−	−	−	−
		60 min.	+	+	+	−	−	−	−
		90 min.	+	+	+	+	−	−	−
		120 min.	+	+	+	+	−	−	−
		19 hr.[2]	+	+	+	+	+	+	−

Controls[4]

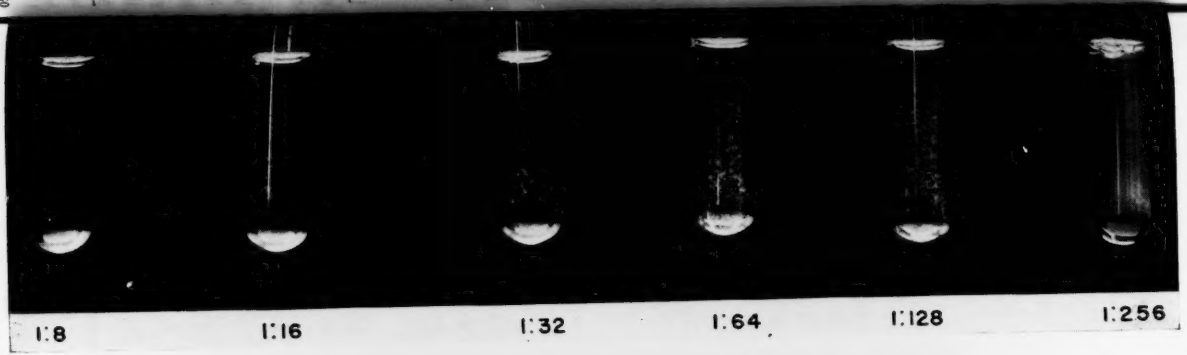
Temperature	Incubation period	Undiluted healthy juice plus saline	Undiluted healthy juice plus rabbit No. 1, serum 1/4	Undiluted healthy juice plus rabbit No. 2, serum 1/4	Undiluted infective juice plus saline	Undiluted infective juice plus normal rabbit serum 1/4
37° C.	30 min.	−	−	−	−	−
	60 min.	−	−	−	−	−
	90 min.	−	−	−	−	−
	120 min.	−	−	−	−	−
	19 hr.[2]	−	−	−	−	−
40° C.[3]	30 min.	−	−	−	−	−
	60 min.	−	−	−	−	−
	90 min.	−	−	−	−	−
	120 min.	−	−	−	−	−
	19 hr.[2]	−	−	−	−	−

[1] Readings were made as either + (precipitate formed) or − (no precipitate).

[2] Icebox.

[3] Water bath.

[4] In the control mixtures, healthy and infective juice were added undiluted to absorbed antisera or normal rabbit serum in a dilution of 1/4.



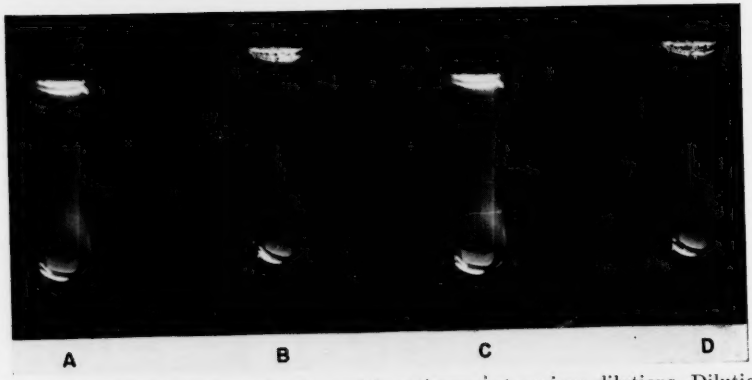


FIG. 1.—Precipitation reaction of sugarcane-mosaic virus with antiserum at various dilutions. Dilutions of antiserum mixed with infective cane juice: A, B, C, and D = control mixtures; A = healthy cane juice plus saline, B = healthy cane juice plus antiserum, C = infective cane juice plus saline, D = infective cane juice plus normal rabbit serum.

and suggest the possibility of using the precipitin reaction in testing for its relationships.

Figure 1 is a photograph of the reaction obtained with rabbit serum No. 1 after 2 hours incubation at 37°C.

SUMMARY

Sugarcane-mosaic infective juice was obtained from infected sugarcane plants of the variety B.H. 10–12. The juice was centrifuged at high speed and the sediment was suspended in phosphate buffer and inoculated into rabbits by the intravenous and intraperitoneal routes. Specific antibodies were demonstrated when the rabbit sera were absorbed with healthy cane juice and had titers of $1/128$ or $1/256$ when tested against mosaic-infected juice by the precipitation technique. The antisera did not react with healthy cane juice after absorption. Normal rabbit serum did not react with the healthy or infective juice used in the tests.

RESUMEN

Se obtuvo jugo infeccioso de plantas de caña de azúcar, variedad BH 10–12, enfermas con el virus del mosaico de la caña. Se centrifugó el jugo a alta velocidad y el sedimento se suspendió en solución de fosfato amortiguador e inoculóse en conejos por vía intravenosa e intraperitoneal.

Se probó la existencia de anticuerpos específicos cuando después de la absorción de los sueros de conejo con jugo de caña sana, se obtuvieron títulos de 1/128 y 1/256 frente al jugo de caña infectado con mosaico Usóse en estas pruebas el método de precipitación.

Los antisueros no reaccionaron con el jugo de caña sana después de la absorción. No se obtuvo reacción alguna del suero de conejos normales frente al jugo infectado o al jugo de caña sana.

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FURTHER STUDIES ON THE MOSAIC OF THE SUGARCANE VARIETY MAYAGUEZ 336

José Adsuar[1]

INTRODUCTION

In 1950, a preliminary report on a mosaic disease of the sugarcane variety of Mayagüez 336 occurring in Puerto Rico was presented (1).[2] The symptoms observed consisted in the appearance of one or two elongated chlorotic streaks with irregular margins on the lower half of the younger leaves; the streaks increased in number and formed a distinct mosaic pattern of normal green islets on a yellowish background.

Our interest was immediately aroused because M. 336 is one of our best mosaic-resistant canes. We decided first to test whether the mosaic under study was transmissible to M. 336 as well as to other varieties known to be either resistant or susceptible to the sugarcane-mosaic virus. Insect transmissions were also attempted using the corn aphid, *Aphis maidis* Fitch.

All efforts at the time to transmit the mosaic to other sugarcane varieties either mechanically or by means of the aphid vector failed. Only M. 336 and sorghum, *Holcus sorghum* L., proved susceptible. The symptoms on sorghum are characterized by a mottling of the leaves very similar to that produced by the sugarcane-mosaic virus.

Although these experiments were preliminary and very limited in extent the possibility was entertained that the virus under study might be a strain of the sugarcane-mosaic virus or an altogether different virus.

Recent and more detailed studies, however, have disclosed that the so-called mosaic of the variety M. 336 is probably identical with the sugarcane-mosaic virus present on the Island.

This paper presents the results of this work.

MATERIALS AND METHODS

In all cases inoculum was prepared by grinding the infected leaves in a meat grinder which had been cooled in the refrigerator. The juice was extracted from the pulp by pressing it through muslin cloth by hand. The beaker in which the juice was collected was kept jacketed with ice. All the apparatus used in the operations was sterilized. Inoculations were performed by dusting the leaves with carborundum and rubbing on the infectious liquid with a cotton swab.

Sorghum, *Holcus sorghum* L., was used as test plant to check the in-

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[2] Numbers in parentheses refer to Literature Cited, p. 21.

fectiousness of the inoculating juices and also in the physical-property studies of the viruses. It was selected for these purposes because of its high susceptibility to both M. 336 and sugarcane-mosaic viruses and also on account of the ease with which it is grown and handled in the laboratory.

The sugarcane plants used in the transmission experiments were selected from healthy stools and planted in 6-inch pots. The sorghum plants were raised from seed in 5-inch pots. After inoculation the plants were kept in a screened house at temperatures between 72° and 95°F.

TRANSMISSION STUDIES

The following varities were inoculated as described under Materials and Methods: B.H. 10–12, Sta. Cruz 12/4, Co. 281, P.O.J. 2878, P.R. 902, and C.P. 29–291. Each variety was inoculated with juice from an infected M. 336 plant showing characteristic symptoms. Table 1 shows the results of the transmission experiments.

Twenty-nine sorghum plants were inoculated to test the infectiousness of the virus of which 10 became infected. As will be seen from table 1, transmission of M. 336 was accomplished in all the varieties tested with the exception of P.O.J. 2878 and P.R. 902.

A parallel transmission series was carried on simultaneously with the above-mentioned varieties using the sugarcane-mosaic virus extracted from B.H. 10–12 as inoculum. The symptoms produced by M. 336 mosaic virus on the susceptible varieties were undistinguishable from those produced by the sugarcane-mosaic virus on the same varieties. When juice from B. H. 10–12 plants previously inoculated with M. 336 mosaic virus and presenting symptoms characteristic of sugarcane-mosaic virus on this variety were inoculated back to variety M. 336, symptoms typical of M. 336 mosaic developed. It was concluded that the difference in symptomatology between the two types of mosaic was a varietal expression.

TABLE 1.—*Results of the transmission experiments using YM-336 mosaic virus from M. 336 as inoculum, 1951*

Date	Variety inoculated	Results[1]
Mar. 29	B.H. 10–12	1/15
29	Sta. Cruz 12–4	6/14
29	Co. 281	4/14
May 18	C.P. 29–291	5/6
Mar. 29	P.O.J. 2878	0/11
29	P.R. 902	0/18

[1] In this and other tables: Numerator = number plants infected; denominator = number plants inoculated.

STUDIES OF PHYSICAL PROPERTIES

The results on transmission presented above led us to inquire further whether there might be differences in the physical properties of the viruses causing the mosaic of the variety M. 336 and the sugarcane-mosaic virus. To test this hypothesis M. 336 mosaic virus extracted from diseased M. 336 plants, and sugarcane-mosaic virus obtained from B.H. 10–12 were inoculated separately into healthy sorghum plants.

Sorghum was used as source of inoculum and also as a test plant in the physical-property studies for the reasons mentioned under Materials and Methods and because symptoms usually appear in less than a week and are easily observable in this plant. In addition, it has been observed that sorghum is much more susceptible than other susceptible plants, including M. 336, to the M. 336 mosaic virus under study.

Each determination was repeated at least four times, and the data presented in each case are representative of the results obtained.

Resistance to Heat

To determine the thermal death point of both viruses, 1 cc. of each mosaic juice was heated in a thin-walled test tube in a serological water bath for 10 minutes at the desired temperature after which the tubes were plunged into cold water and the inoculate was used on young sorghum seedlings.

TABLE 2.—*Thermal inactivation of YM-336 and sugarcane-mosaic viruses*

Temperature (°C.)	YM-336 virus	Sugarcane-mosaic virus
(1)	35/152	26/125
45°	9/66	3/45
50°	0/62	0/38
55°	0/53	0/28
60°	0/64	0/53

[1] Untreated juice.

TABLE 3.—*Dilution end point of YM-336 and sugarcane-mosaic viruses*

Dilution	YM-336 virus	Sugarcane-mosaic virus
(1)	35/152	26/125
1:10	15/42	2/38
1:100	0/60	1/32
1:1,000	0/44	0/25
1:10,000	0/59	0/29

[1] Undiluted juice.

Results are presented in table 2. It will be seen that the thermal death point of both viruses occurred at about the same temperature.

Dilution End Point

To determine the dilution end point of the viruses various dilutions of each mosaic-leaf juice were made with sterile distilled water.

Results are presented in table 3. The results demonstrate that the dilution end point was virtually the same for both viruses.

Longevity

The longevity in vitro was determined by storing the infectious juices at room temperature (28° to 30°C.) for various lengths of time.

The results obtained are given in table 4. The data indicate that the two viruses became inactivated in 24 hours at room temperature.

INSECT TRANSMISSION

Although we had been unable to transmit the M. 336 mosaic by means of the aphid vector, *A. maidis* Fitch, as reported in the first paper cited, trials were continued in an effort to elucidate this point. The aphids were reared on healthy corn plants grown for that purpose. The insects were collected by means of an aspirator, placed directly on the infected plants,

TABLE 4.—*Longevity of YM-336 and sugarcane-mosaic viruses*

Time (hours)	YM-336 virus	Sugarcane-mosaic virus
0	29/33	14/23
2	9/25	11/24
4	11/25	14/33
6	4/17	1/25
8	5/18	4/34
24	0/24	0/20

TABLE 5.—*Transmission of YM-336 mosaic virus using numerous corn aphids,* A. maidis *Fitch, 1951*

Date	Virus source	Plant inoculate	Results
Mar. 19	Sorghum	M. 336	2/4
19	do.	Sorghum	2/48
29	do.	M. 336	0/1
Apr. 20	do.	do.	2/8
24	do.	do.	1/3
May 18	B.H. 10–12	do.	2/2
18	Sta. Cruz 12/4	do.	1/2

and permitted to feed for at least 24 hours. They were then removed by the same method and placed on the test plants.

The plants to be tested were grown from healthy seed and placed in wire-screened cages. In nearly all the trials one or two leaves of the plants to be tested were covered with cellophane bags and the infected aphids dropped in. In one case an infected sorghum plant on which aphids have been placed was put in contact with healthy plants in one of the cages. Results of the transmission experiments are given in table 5. Obviously transmission occurred in many instances.

SUMMARY

Transmission of the mosaic virus present on the sugarcane variety M. 336 is reported.

The virus was transmitted mechanically from mosaic-infected M. 336 to the varieties, B.H. 10–12, Sta. Cruz. 12/4, and C.P. 29–291. No transmissions were obtained to the varieties P.O.J. 2878 and P.R. 902, which are resistant to the sugarcane-mosaic virus.

The mosaic symptoms produced by the YM-336 virus on B.H. 10–12, Sta. Cruz 12/4, Co. 281, and C.P. 29–291 were indistinguishable from the symptoms produced on these same varieties by the sugarcane-mosaic virus.

Comparative studies were made of the physical properties of the M. 336 mosaic virus and the sugarcane-mosaic virus obtained from B.H. 10–12. No differences were observed in the properties of the two viruses. Both were inactivated at a temperature of around 45°C., had a dilution end point of 1:10, and did not survive for more than 24 hours at room temperature.

The YM-336 virus was transmitted successfully by means of the corn aphid, *A. maidis* Fitch, from infected sorghum, B.H. 10–12, and Sta. Cruz 12/4 to the variety M. 336.

RESUMEN

Se informa la transmisión del virus causante del mosaico de la variedad M-336.

El virus se transmitió artificialmente por frotación del jugo de caña M-336 enferma, a caña sana de las variedades BH 10–12, Santa Cruz 12/4, Co. 281, CP 29–291. No pudo, sin embargo, transmitirse a las variedades POJ 2878 y PR 902 las cuales sabemos son resistentes al virus de la caña de azúcar.

Los síntomas producidos por el virus causante del mosaico de la caña M-336 en las variedades BH 10–12, Santa Cruz 12/4, Co. 281 y CP 29–291 son idénticos a los producidos por el virus causante del mosaico de la caña de azúcar en esas mismas variedades.

Se verificaron estudios comparativos respecto a las propiedades físicas entre el virus del mosaico de M-336 y el de la caña de azúcar extraído de la variedad BH 10–12. No se observaron diferencias en cuanto a dichas propiedades físicas. Ambos virus se inactivan a temperatura de 45° C., no resisten dilución de más de 1:10 partes de agua sin inactivarse, y no sobreviven por más de 24 horas en el jugo extraído y sometido a la temperatura del laboratorio (28°–30° C.).

Se logró transmitir el virus causante del mosaico de la variedad M-336 a plantas sanas de esa misma variedad por medio del pulgón del maíz, *A. maidis* Fitch, usando como fuente de inóculo plantas de sorgo, BH 10–12 y Santa Cruz 12/4 enfermas con dicho virus.

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SUCROSE CONTENT OF SUGARCANE AS AFFECTED BY MOTH-BORER, *DIATRAEA SACCHARALIS* (FABRICIUS), INFESTATION[1]

Luis F. Martorell and Ishver S. Bangdiwala[2]

INTRODUCTION

The sugarcane moth stalk-borer, *Diatraea saccharalis* (Fabricus), has been and still is the most important sugarcane insect pest in Puerto Rico. Early reports on the attack of this insect appeared in a publication by Fernando López Tuero (4)[3] in 1895. As translated from the Spanish, he wrote:

> If the injury of the insect were confined to the cane which it destroys, it would not be so serious but the galleries which it constructs give access to the air, and the juice of the cane in the region of the wounds becomes subject to the usual ferments, communicating the fermentation from particle to particle in the juice and from fibre to fibre, until the juice of the cane is totally or to a great degree changed.
>
> In the older abandoned plantations the ravages of the borer are likely to be so great as to make it useless to harvest the crop. Even though some of the stalks remain sound, selection during cutting would not be practical, and, if the injured cane is sent to the mill, the altered juice will corrupt all of the juice and will produce a sugar of the lowest grade.

L. D. Van Dine (7) in 1912, writing about the damages of the borer said:

> The effect of the borer injury on the cane juice is only one of the several losses the planter suffers from this pest. The destruction of the inner tissues of the stalk causes a loss in weight and retards the growth. Where the cane is heavily infested, many stalks will be rendered worthless and will, of necessity, be discarded when harvesting

[1] This work would not have been possible without the cooperation of Luce & Co.' Aguirre, P. R. To all the personnel of Luce & Co., which cooperated in these investigations the writers are most grateful, particularly to M. S. Baker, In Charge of Agricultural Research Department; C. H. Burleigh, Agronomist, Research Department; T. B. Fraser, Field Manager, Cortada Division; and Néstor Ramos, Assistant Field Manager, Cortada Division. The writers appreciate the assistance given to them in their fieldwork by Wilfredo Cruz and Gaspar Rivera. Thanks are given to B. G. Capó and G. N. Wolcott for reading, criticism, and suggestions in preparing this paper. The writers are also indebted to Leonardo Igaravidez, Assistant Chemist, for his careful analysis of the sugarcane juices at the Chemistry Laboratory and to A. Cruz Miret, who cooperated in the statistical calculations in this work. Juan L. Moreno, of the Department of Entomology, and Esther Pérez of the Agricultural Extension Service, are responsible for the figures. Félix Román and Edmundo Silva of the Department of Agricultural Economics, helped in supplying information given in table 5.

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[3] Numbers in parentheses refer to Literature Cited, pp. 36–7.

the crop, giving a lower tonnage. The stand is reduced in plant cane by the nongermination of eyes that have been injured by the borer in the cuttings used as seed. The stand of cane is further reduced in both plant and ratoon crops by the young shoots that are killed out by the destruction of the "heart" by the young borers. The wounds in the stalk caused by the borer offer an entrance to diseases and consequent decay. There is greater difficulty in grinding borer-infested canes for the reason that the juice is decreased and the fibre increased and the stalks are proportionally harder. Borer-infested stalks are easily broken by the wind and by the laborers in working the crop.

The attack of the borer in the sugarcane stalks is supposed to produce indirect losses in sucrose content by opening the way of entrance to rot organisms, such as fungi and bacteria, capable of producing chemical reactions which invert the sugar, thus lowering the sucrose content of the canes.

Our study dealt only with the direct losses of available sucrose in the juices as affected by the borer, disregarding all other losses caused by the insect in the fields.

PAST INVESTIGATIONS

It would be very difficult to cite all the previous investigations related to the losses in sucrose content and purity of the juice from the attack of the moth-borer on sugarcane. Probably the first investigation of this kind in Puerto Rico was made in 1911, by D. L. Van Dine, Entomologist for the Experiment Station of the Sugar Producer's Association of Porto Rico. Van Dine summarized his work (7) as follows:

> There is a direct loss in sugar and decided reduction in the purity of the juice of cane infested by the moth stalk-borer. This loss in Porto Rico exceeded 670 pounds of sugar per acre of cane in which the infestation was not apparent except upon examination, the yield averaging 41 tons of cane per acre and the stalks being normal and healthy in appearance. The loss increases in direct proportion to the number of joints of the cane stalks infested by the borer. There is more fibre and less juice in borer infested cane. The actual weight of borer infested cane is less than that of sound cane and it is considered that the juice deteriorates more rapidly in infested cane when cane is allowed to stand without being crushed for any length of time after harvest.

Earlier than this were the reports of Stubbs and Morgan (6) from the Louisiana Agricultural Experiment Station in 1902. These investigators reported a loss in weight due to the borer of 4.98 tons of cane per acre, the average yield falling from 23.39 to 18.41 tons per acre. The factory loss was estimated to be 25 pounds of sugar per ton of cane harvested. These data were obtained from general averages of the records of one factory for 11 years during which the plantation was comparatively free from borer infestation and for 3 years of borer attack, on an area of 3,227 acres. The average loss in weight from the decrease in yield amounted to 16,061

tons of cane per year and the average loss in sugar as a result of the borer injury on the cane juice amounted to 741 tons of sugar per year. Thus, the figures indicated a field loss of 16,041 tons of cane and a further factory loss of 741 tons of sugar per year for this one plantation.

During the year 1910, T. C. Barber (1), carrying on investigations at Audubon Park, New Orleans, La., regarding the injury to cane juice by the moth-borer, also obtained results on the direct losses in sucrose as affected by borer attack. Mr. Barber summarized his experiments as follows:

> It should be noted as having a bearing on all of these analyses that the lower the purity of the juice the lower is the percentage of total sucrose that is recoverable in the form of sugar. Therefore the percentage loss of sugar in the impure samples somewhat exceeds the loss of sucrose. The sucrose which can not be recovered is approximately equal in amount to the glucose present. On this basis the present experiment would show a production of 176.26 pounds of sugar per ton for the borer-free cane, while the borer-infested cane would give 138.97 pounds of sugar, a loss of 37.29 pounds per ton of cane, equaling a loss of 21.16 per cent sugar, which is 1.83 per cent in excess of the sucrose loss.
>
> It may be computed from the figures in Table VII that an acre of borer-free cane yielding 25 tons of cane of the above quality would yield 4,716.25 pounds of sucrose per acre, while if it were infested to the same degree by borers, the yield under similar conditions would be 23.92 tons of cane and 3,637.75 pounds of sucrose per acre—a loss of 1,078.50 pounds sucrose per acre.

For many years agricultural investigators have been working on the moth-borer problem in the State of Louisiana. In 1945, Ingram and Dugas (3) reported on the losses resulting from sugarcane-borer injury to cane. Among other things revealed in their investigation, they said:

> A summary of the results for 1945 together with those for the entire period during which these surveys have been conducted, is given in table 1. It may be noted that the estimated average percentage of joints bored in 1945 was 16.5 as compared with 13.9 in 1944 and an average of 15.2 for the period of the survey, 1935–1945. However, the 1945 average was lower than for 1941, 1942 or 1943.
>
> The value of the 1945 Louisiana sugarcane crop to the grower was estimated at $35,660,000 by the Bureau of Agricultural Economics of the U. S. Department of Agriculture in its December 26, 1945, report. Careful observations indicate the percentage of sucrose lost because of the borer to be about one-half the percentage of joints bored, and the loss due to reduction in weight of cane delivered to the mill to be one-half the sucrose loss. Thus, with an average of 16.5 percent of the joints bored the borer caused a loss of 12.375 percent, or nearly $5,000,000, to Louisiana sugar farmers in 1945.

One of the latest studies was carried on in Cuba, at the Experimental Station of Central Gomez Mena by J. G. Salinas (5) who concluded that: "The borer has caused damages equivalent to $0.74, as an average per each 100 'arrobas' of cane (2,500 pounds) ground during the harvesting season of 1949."

During the same year J. W. Ingram, E. K. Bynum, and others (2) at the Houma Laboratories in Louisiana, investigating the sugarcane-borer situation in Louisiana, found the following:

> On an average 22.5 percent of the joints were found bored in a systematic survey of borer injury conducted at harvesttime in 1949, in representative Louisiana cane fields by the Houma Laboratory, in cooperation with the Louisiana Agricultural Experiment Station. This percentage is much higher than the average of 14.3 percent of joints bored during the period 1935–48 and is the highest infestation observed since the present method of survey was initiated in 1935. On the basis of data indicating a loss of 0.5 percent of total sucrose for each 1 percent of joints bored and a loss in weight of 0.25 percent for each 1 percent of joints bored, it is estimated that the crop loss in 1949 amounted to 16.8 percent. By applying this percentage of loss to the preliminary estimate on a 39 million dollar sugarcane crop in 1949 by the Louisiana Crop Reporting Service, it is estimated that the sugarcane borer caused a loss of over 7 million dollars in the State in 1949.

A study having as its objective the determination of the effects of the borer injury on sugarcane stalks in terms of the direct loss of sucrose in the cane juices, was started during the spring of 1950.

SAMPLING AREA USED

Sugarcane samples were collected from the following colonias, all the property of Luce & Co., S. en C.: Juana Díaz, Amelia, Centro, Florida, and Potala. These colonias are in a group covering an area of several thousand acres from El Pastillo, near Losey Field in the west up to the outskirts of the town of Santa Isabel in the east. The area studied is fairly representative of the south coast of Puerto Rico, as far as rainfall, humidity, and other conditions are concerned.

The work, which covered a period of two harvesting seasons—1950 and 1951, included the following number of fields studied in the different colonias: Amelia, 5 fields; Florida, 2 fields; Potala, 1 field; Centro, 3 fields, and Juana Díaz, 9 fields. Over 1,000 cane samples were collected in the 20 fields under study.

PROCEDURE

Collection of Samples

Cane stalks were collected at random from the fields under study which were going to be harvested 3 or 4 days after the collection, thus assuring perfect maturity of the cane. Usually 200 or 300 whole cane stalks were collected at random from each field. The laborers, six or eight in number, were trained to perform this work as accurately as possible in order to obtain representative samples of the fields studied. The cane was cut as close to the ground and as close to the top as possible to include top joints also in our investigations. The percentage of borer infestation was estimated by

dividing the total number of joints bored by the total number of joints (including the bored ones) in the 10 canes included in each sample. In this way was obtained what is termed the "percentage of bore-infested joints."

Classification of Samples

The sugarcane stalks collected in the fields by the method described were classified into bored and nonbored stalks.

Whole-stalk samples (stalks cut at the base close to the soil and topped where the terminal bud is located) were classified in two groups: Bored, and nonbored or healthy canes as they were called in the field. For example, if 200 or 300 canes were collected from field No. 12, the bored canes were first separated from the nonbored ones. If 150 canes out of 200 were bored, 15 samples (10 canes each) of bored canes and 5 of nonbored or healthy canes could be made. The percentage of infestation on each sample was recorded after careful determination. These field data were accurately recorded on especially prepared field blanks. The samples were identified by numbers and letters so as to determine the identity of those that had to be taken from the field to the laboratory for grinding and analyzing the juices. A very simple system of labelling the samples were followed which avoided confusion or rarely led to a mistake in their further identification once they were out of our control.

Canes collected at Colonia Juana Díaz, from field No. 12, were labelled as follows: J.D.–12–H–1; J.D.–12–H–2; J.D.–12–H–3, etc., thus indicating that the samples originated in that Colonia and in field No. 12, the H standing for healthy cane, the last number being the sample number. If the samples were from the bored canes, the same system was followed, but a B was used instead of the H to indicate bored canes. The different samples originating in different colonias were then easy to identify by using J. D. for Juana Díaz; P. for Potala; F. for Florida; C. for Centro, and A. for Amelia. More than 1,000 samples were handled in this way without losing track of any. These were always identified on the laboratory sheets once the analysis of the juices was delivered from the Chemistry Department. The samples were tied in three places with a very strong twine, and two label cards were tied to each sample giving the exact identification number.

Other whole-cane samples were taken and subdivided into tops, centers, and bases as follows: 400 or 500 canes were collected at random from a field and separated into healthy and bored classifications.

Center, top, and base samples were obtained from the healthy canes by taking samples of 10 healthy canes and then dividing these systematically into tops, centers, and bases. The samples were well tied up with strong twine, and properly labelled for sending to the laboratory.

Infested tops, centers, and bases were obtained also from the bored

canes. Separate samples of these tops, centers, and bases were made, 8 to 10, to each sample. The percentage of bore-infested joints was determined and recorded for each sample. These were then labelled and packed following more or less the same system as was used with the whole-cane samples.

The division of whole canes into tops, centers, and bases, was made in order to determine the loss of sucrose, if any, caused directly by the moth-borer infestation in the different sections of the cane as well as in the whole cane. On the south coast of Puerto Rico the highest percentage of joints infested is invariably found in the top of the stalks. The lowest borer infestation is usually at the base or bottom of the cane. The reason for these differences in borer infestation will be explained subsequently.

The top was regarded as the four or five joints close to the terminal bud in the stalk. The top is really the green or immature part of the stalk, the number of joints varying according to the cane variety. The base of the cane is made up of the lower four or five bottom joints; in many long canes this base or bottom extends up to seven or eight joints. The center is usually the longest sample, including 8 to 10 or more joints at times.

The senior writer has not only used this system of classification in the determination of bore-infested joints for this particular study, but also in 4 years of investigations on the moth-borer at the south coast of Puerto Rico. The percentage of borer infestation of the fields under study has been recorded in these three ways as well as the total percentage of joint and of stalk infestation. This system of determination has provided very interesting facts related to the borer which the authors hope to present and discuss in future publications.

The samples thus collected, labelled, and packed were taken from the south coast to the Río Piedras laboratory daily, so that the canes were ground and the juice analyzed from 15 to 24 hours after harvest. At the Río Piedras laboratory the samples were ground in a Squier hydraulic mill. The juice extracted from each sample was collected and weighed and a representative sample immediately sent to the chemistry laboratory where it was analyzed with little loss of time. The same procedure was followed with the samples of this study in the fields, the mill, and the laboratory.

ESTIMATION OF THE EFFECT OF MOTH-BORER INFESTATION

To estimate the effect of the moth-borer infestation on the sucrose content of sugarcane, the nonbored and bored samples were considered together, the whole data falling into four distinct classes, i.e., samples from the whole cane, the tops, the centers, and the bases.

The study of the regression of the percentage sucrose content of the cane on the percentage infestation was made separately for each of these four classifications.

TABLE 1.—*Regression coefficients for whole-cane samples, 1950–51*

Year 1950		Year 1951	
Field identification No.	Regression coefficient[1]	Field identification No.	Regression coefficient[1]
		2	−0.1293**
		3	.1393**
1	−0.03175	4	.03012
2	.02818*	10	.07496**
3	.02246	11	.02505
7	.02944	12	.006222
9	.03110*	15	.01416
16	.02584	16	.01670
22	.05239*	18	.02522
23	.02853*	19	.05331
27	.03945	30	.01342
Average	−0.03280**		−0.03679**
Average regression coefficient for whole cane			−0.03549**

[1] ** Probability level of significance: 1 percent; * probability level of significance: 5 percent.

Whole Cane

The data for the study of whole-cane infestation were available from 360 samples (each sample of 10 canes, making a total of 3,600 canes) selected at random over a period of two crop seasons from 20 different fields in the area mentioned above. On the assumption of existence of a linear relation between the available sucrose and the degree of infestation, the trend of the regression was studied for each of the fields separately, and the regression equations were obtained. The coefficients of regression are given in table 1.

The effect of infestation on sucrose was observed to be detrimental in all the field samples. The range of the percentage decrease in sucrose was from 0.006 to 0.139 per 1-percent increase in infestation. Out of the 20 fields studied for whole-cane infestation, 8 showed evidence of significant effect. On testing these regression coefficients for homogeneity, however, it was found that they did not differ significantly from one another. This test led to estimating the average effect of infestation for whole cane over all the fields. Therefore, after eliminating the variation arising from the differences in the fields and that from the differences in the periods over which the samples were collected, the average estimation equation ob-

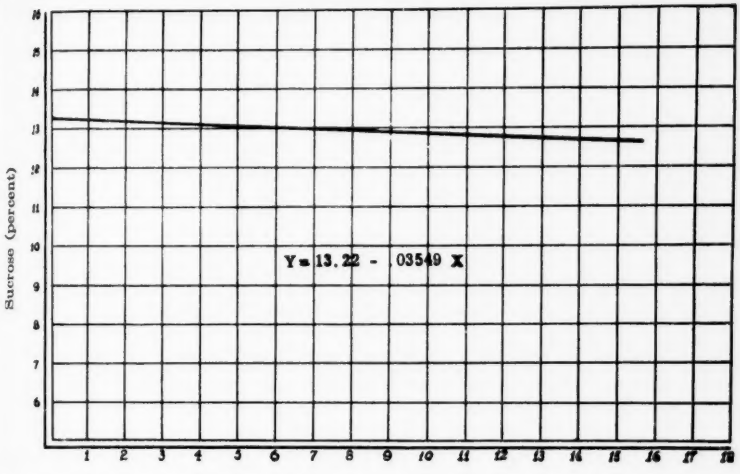

FIG. 1.—Line of regression of available sucrose in whole-cane on percentage infestation by moth-borers.

tained for the whole-cane infestation was:

$$Y = 13.22 - 0.03549\ X$$

where Y = percentage of available sucrose in whole cane, and X = percentage borer infestation of whole cane.

On the average a 1-percent increase in infestation was found to reduce the sucrose content of whole cane by about 0.035 percent. This linear coefficient of regression was, on test, found to have a very high significant difference from zero. The regression line is shown in figure 1.

The samples for the year 1950 showed this effect to be only 0.033 percent, while for the year 1951—was 0.037 for every 1-percent increase in infestation of the whole cane. The field coefficients for each year did not show significant differences among themselves.

Tops

A study similar to the one for whole-cane samples was made for the samples collected from tops of the sugarcane. One hundred and twenty-eight samples (usually 8 to 10 tops to the sample, or over 1,200 tops) were available from 13 different fields from the same area, during one crop only.

TABLE 2.—*Regression coefficients for samples from sugarcane tops*

Field identification No.	Regression coefficient[1]	Field identification No.	Regression coefficient[1]
1	−0.009989	25	−0.01729
5	.05438	26	.04036
8	.03721**	28	.07975**
9	.01166	29	.08304*
17	.07407*	32	.01306
20	.009598	33	.03846
22	.2508		
Average regression coefficient for tops			−0.03904**

[1] ** Probability level of significance: 1 percent; * probability level of significance: 5 percent.

The regression equations were obtained for each of these fields, on the same assumption of linear relationship as for the whole cane. The coefficients of regression are shown in table 2. It is clear that the infestation also had a detrimental effect on the sucrose content of the cane tops in all the fields. The effect, however, varied from field to field, ranging from essentially −0.0096 to −0.251 percent for 1 percent of infestation. Four of these coefficients were found to be significant.

In spite of these wide fluctuations in the intensity of the detrimental effect in different fields, their regression coefficients failed to show sufficient evidence of difference among themselves. Hence, the average regression of the percentage of sucrose for tops on the percentage infestation was computed after eliminating the variation due to the differences in the fields only, there being no variation due to differences in time, as the samples for tops were all collected at once. The regression equation was:

$$Y = 9.33 - 0.03904\,X$$

where Y = percentage of available sucrose in tops, and X = percentage of borer infestation in tops, showing that the effect of infestation in tops was to reduce the sucrose content by 0.039 percent for every 1-percent increase in borer infestation. Figure 2 shows the estimated average regression line fitted to data for the tops. Like the average regression coefficient for whole cane, the coefficient for tops also was found to be highly significant as compared with the zero effect.

Centers

The data for infestation in sugarcane centers were derived from 188 random samples (8 to 10 centers to a sample, or over 1,800 centers) from 14

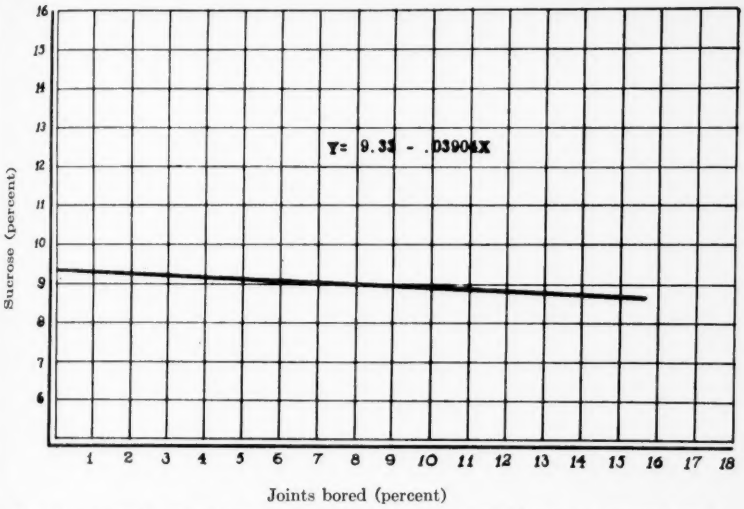

FIG. 2.—Line of regression of available sucrose in tops of cane on percentage infestation by moth-borers.

TABLE 3.—*Regression coefficients for samples from sugarcane centers*

Field identification No.	Regression coefficient[1]	Field identification No.	Regression coefficient[1]
6	−0.08892**	25	−0.005013
8	.07673**	26	.08430**
13	.04662	28	.05776*
17	.08049*	29	.02814
20	.04057	31	.05906*
21	.04718	32	.05650*
24	.05315	33	.02422
Average regression coefficient for centers			−0.05333**

[1] ** Probability level of significance: 1 percent; * probability level of significance: 5 percent.

different fields collected for 1 crop only. The regression coefficients arrived at for different fields are given in table 3. Here also, all of the fields showed the detrimental effect of infestation, with more than half of them showing a significant difference from zero. Although the coefficient varied from about −0.0050 to −0.089 on testing for homogeneity, no significant differences were found. Hence, after elimination of the variation due to the difference

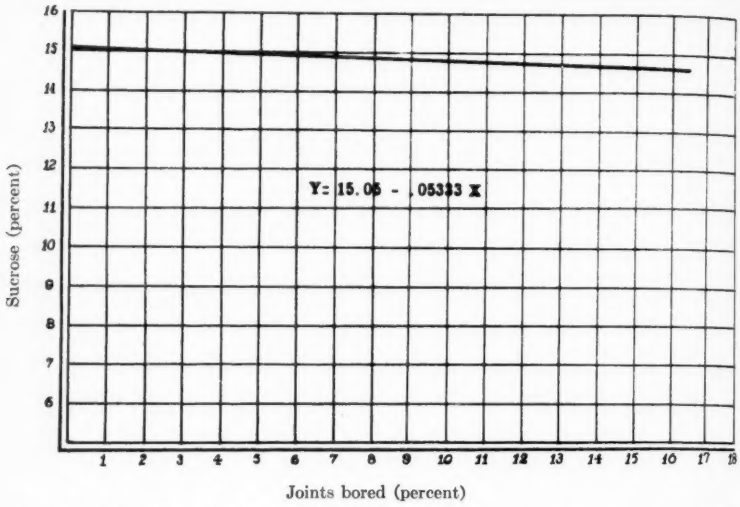

FIG. 3.—Line of regression of available sucrose in centers of cane on percentage infestation by moth-borers.

in the fields, the average regression equation was obtained as:

$$Y = 15.05 - 0.05333\ X$$

where Y = percentage of available sucrose in centers of cane, and X = percentage of borer infestation in centers.

The regression coefficient was highly significant too. Figure 3 shows the estimated line plotted to fit the data for centers.

Bases

For the study of sucrose reduction, if any, in the bases of the cane, 200 samples (10 bases per sample or around 2,000 bases) of 1 crop collected at random from 16 fields, were available. Estimation equations were computed for these fields having regression coefficients presented in table 4. Here again the coefficients for different fields did not show enough evidence of difference among themselves, even though they ranged from about -0.0667 to -0.375, all showing detrimental effects of infestation. The average regression equation obtained after eliminating field differences, was:

$$Y = 14.67 - 0.02573\ X$$

where Y = percentage of available sucrose in bases of canes, and X = percentage of borer infestation in bases.

TABLE 4.—*Regression coefficients for samples from sugarcane bases*

Field identification No.	Regression coefficient[1]	Field identification No.	Regression coefficient[1]
6	−0.02752	24	−0.04093
8	.04019*	25	.01328
9	.01254	26	.06435*
13	.01692	28	.02661
14	.03747**	29	.006715
17	.01979	31	.01218
20	.02943	32	.01582
22	.05237	33	.2696*
Average regression coefficient for bases			−0.002573**

[1]** Probability level of significance: 1 percent; * probability level of significance: 5 percent.

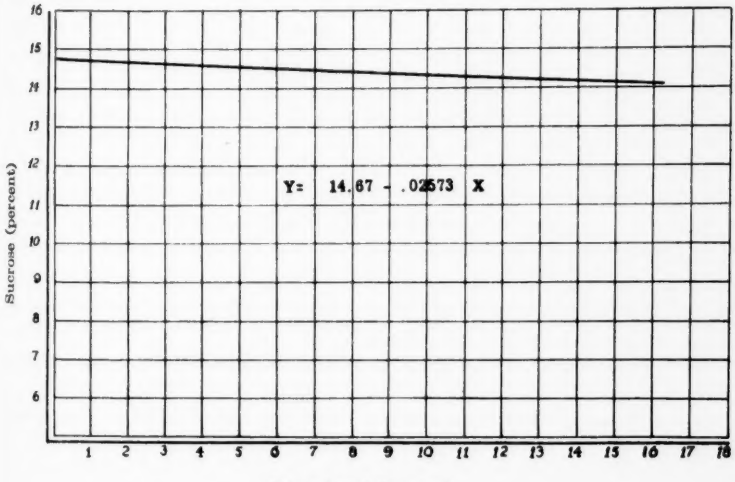

FIG. 4.—Line of regression of available sucrose in bases of cane on percentage infestation by moth-borers.

The line is shown plotted in figure 4. Although only 4 out of the 16 coefficients for fields showed significant detrimental effects, the average regression was found to be highly significant.

OBSERVATIONS AND ECONOMIC IMPLICATIONS OF FINAL RESULTS

This study on the direct losses of or reduction in available sucrose caused by the sugarcane moth-borer is a preliminary attempt to develop a sound

basis for figuring the damage to our sugarcane growers caused by this insect. It is our aim to continue these investigations on a larger scale. The work as published is not final, since there is great opportunity for further research.

From the study made separately for each of the classifications discussed above it was found that infestation reduced the normal available sucrose content of the cane in all four, the effect being greatest in the center portion of the stalk and least in the base. The effect was found always to be very remarkable in that the regression coefficients showed highly significant differences from the zero value.

For practical purposes and for actual application of the study in fieldwork we shall consider only the factor of average reduction of sucrose content as established in the study of whole canes in which healthy and bored canes were used. Thus, a reduction of 0.03549 percent of available sucrose was found per 1 percent of joint infestation caused by moth-borer. If this factor is multiplied by the percentage of joint infestation in any area, and the result is multiplied again by the average tons of cane produced per acre, one is able to obtain the loss of available sucrose in tons per acre. If the result is then multiplied by 2,000, the loss is obtained in pounds of sugar lost per acre. If the price of sugar per pound was then multiplied by the pounds lost per acre one obtained the loss in dollars per acre and consequently in any given area. Calculated thus, the losses caused by moth-borer attack in Colonia Juana Díaz, at Santa Isabel, Puerto Rico (property of Luce & Co.) during the years 1950, 1951 and 1952 are shown in table 5.

The losses for the 3 years amounted to $49,326 for that Colonia only. This figure will give an idea of how much money is lost every year by the sugarcane industry from the direct damage of this insect to sugarcane juices, independently of other damage it produces.

The exact figure for the average joint infestation for Puerto Rico is

TABLE 5.—*Sugar production and estimated losses caused by moth-borer infestation of cane at Colonia Juana Díaz, Santa Isabel, P. R., 1950–52*

Harvest period	Area harvested[1]	Cane[1] per acre	Average price of sugar per pound	Joint infestation (average for year)	Loss of sucrose per acre	Total loss of sucrose in the year	Total loss
	Acres	*Tons*	*Cents*	*Percent*	*Pounds*	*Tons*	*Dollars*
1950	872	42.75	5.931	9.01	273.60	119.29	14,150
1951	742	51.42	6.057	8.49	309.60	114.86	13,914
1952	866	56.83	6.00[2]	10.14	409.18	177.18	21,262

[1] Information courtesy of M. S. Baker, Agricultural Research Department, Luce & Co., Aguirre, P. R.

[2] Approximate price of sugar per pound in N. Y. market (average for year 1952).

TABLE 6.—*Estimated Puerto Rican sugar production and losses caused by moth-borer infestation, 1940–51*

Harvest period	Total area harvested[1]	Cane[1] per acre	Average price of sugar per pound[1]	Loss of sucrose per acre	Total loss of sucrose in the year	Total annual loss
	Acres	*Tons*	*Cents*	*Pounds*	*Tons*	*Dollars*
1940	252,969	34.77	2.786	222.12	28,094.74	1,565,439
1941	236,296	32.78	3.378	209.40	24,740.19	1,671,447
1942	307,612	32.54	3.739	207.88	31,973.19	2,390,955
1943	310,225	27.94	3.740	178.48	27,684.48	2,070,799
1944	280,353	19.98	3.743	127.64	17,894.93	1,339,614
1945	288,617	27.70	3.750	176.96	25,536.83	1,915,262
1946	303,307	24.85	4.589	158.74	24,073.48	2,209,464
1947	325,211	28.55	6.217	182.38	29,655.99	3,687,426
1948	336,285	28.37	5.545	181.24	30,474.15	3,379,583
1949	353,385	31.12	5.807	198.80	35,126.47	4,079,588
1950	367,093	28.91	5.931	184.68	33,897.37	4,020,906
1951	366,404	28.66	6.057	183.09	33,541.72	4,063.244

[1] Figures for the years 1940 to 1948, obtained from the Annual Book of Statistics of P. R., fiscal year 1949–50, Economic Development Administration, Office of Economic Research, San Juan, P. R. Figures for 1949–51, from Annual Reports for 1950–51 and 1952, of the Caribbean Office, Production and Marketing Administration, U. S. Department of Agriculture, San Juan, P. R.

unknown. However, if we take 9 percent as a general average on the basis of acres of sugarcane harvested in tons of cane per acre, and the average price of sugar for the years 1940 to 1951, the losses of sucrose caused by the insect can be estimated. The figures are shown in table 6.

The total value loss of sucrose amounted to $32,393,727 for the period between 1940 and 1951, or an average yearly loss of about $2,500,000. The figures are comparable to the losses obtained in the State of Louisiana, although the percentage of borer infestation there is estimated to be twice as large as that for Puerto Rico.

Considering the losses caused by this pest to the sugarcane industry, every effort should be made to prevent them. We are still actively seeking measures for the control of this important insect pest.

SUMMARY

More than 1,000 samples of stalks of sugarcane were milled and their juices analyzed in attempting to obtain a more accurate estimate of the losses caused by infestation of sugarcane in Puerto Rico by the moth stalk-borer, *Diatraea saccharalis* (Fabricius). The samples were divided into (1) whole-canes unbored, (2) whole-canes bored, (3) tops unbored, (4) tops bored, (5) central portions unbored, (6) central portions bored, (7) bases unbored, and (8) bases bored.

The statistical analyses showed that the highest percentage of sucrose in cane is found in the central portion, less is found at the base, and the least in the top joints.

By using a factor of 0.03549 (as determined by the junior author), which represents the loss of available sucrose per 1 percent of joint infestation, one can calculate the losses of sucrose caused by moth-borer damage in any given area.

Thus it was found that Colonia Juana Díaz, near Santa Isabel, P. R. had an estimated total loss of $49,326 in the 3 years 1950, 1951, and 1952, from borer injury. It is estimated that the average annual losses in Puerto Rico amounted to approximately $2,500,000 in the 12-year period from 1940 to 1951.

RESUMEN

Con el fin de estimar con mayor precisión los daños que causa el taladrador del tallo de la caña, *Diatraea saccharalis* (Fabricius), en Puerto Rico, se molieron más de mil muestras de caña de azúcar cuyos jugos fueron debidamente analizados. Las muestras se dividieron en ocho grupos, a saber: (1) cañas enteras sanas, (2) cañas enteras taladradas, (3) canutos superiores del tallo sanos, (4) canutos superiores del tallo taladrados, (5) canutos centrales del tallo sanos, (6) canutos centrales del tallo taladrados, (7) canutos inferiores del tallo sanos, y (8) canutos inferiores del tallo taladrados.

El análisis estadístico demostró que el porcentaje más alto de sacarosa en la caña se encuentra en la parte central del tallo, es menos en la base y aún menos en la parte superior del tallo.

Se determinó que el factor de 0.03549, que representa la périda de sacarosa aprovechable por cada por ciento de infestación (basado en el por ciento de canutos taladrados) puede usarse para calcular los daños que causa este insecto en cualquier zona cañera de Puerto Rico. Por lo tanto, se estimó que la Colonia Juana Díaz, de la Central Cortada, en Santa Isabel, P. R., tuvo un pérdida en total para los años 1950, 1951, y 1952, de $49,326 como consecuencia de los daños causados por el taladrador del tallo. El promedio de los daños causados por este insecto en Puerto Rico durante los últimos 12 años, 1940–1951, inclusive, se estima en $2,500,000 anuales.

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INEFFECTIVENESS OF THE OVERHEAD-IRRIGATION METHOD FOR THE APPLICATION OF INSECTICIDES TO CONTROL THE SUGARCANE MOTH STALK-BORER, *DIATRAEA SACCHARALIS* (FABRICIUS)[1]

Luis F. Martorell[2] *and Calvin H. Burleigh*[3]

INTRODUCTION

The uneven topography of Hacienda Santi or Juana Díaz, near central Cortada, Santa Isabel, P.R., makes the distribution of irrigation water to fields of sugarcane very difficult by ordinary gravity methods. The light and porous soils of the area also offer an irrigation problem, since much water is lost by seepage and is never used by the cane. To solve this problem, a system of overhead irrigation was installed using a central pumping station to distribute the water through a series of subterranean pipes, 6 inches in diameter, terminating in 31 vertical risers or towers, hereafter referred to as towers, through each of which the water could be applied from a greater height than that of fully grown cane in adjoining or slightly overlapping circular areas of 2½ acres.

The distribution of the water was quite even within the area, as was proved by collections in a series of pails spaced at 10-foot intervals from the base of the towers to the outside of the irrigated area. Each revolution of the nozzle at the top of the tower had a duration of about 10 minutes, and 6 revolutions were required to apply 0.994 inch of water per acre to each area. The towers were operated one by one; while one was in operation the others were closed, and as soon as a tower was about to be closed the next one following in schedule was opened immediately. In this manner there was always a tower in operation during the irrigation periods.

To render the irrigation most effective the operations were conducted at night when the wind velocity was much lower than during the day. In the southcoast of Puerto Rico, as elsewhere in the Island, the velocity of the wind drops considerably after 6:00 p.m. and becomes almost zero during the night, when only a zephyr blows. At this time the overhead irrigation worked best.

[1] The writers are grateful for the full cooperation that was given to them in this investigation by: Maybin S. Baker, Head, Research Department; T. B. Fraser, General Field Manager, Cortada Division, both from Luce & Co., S. en C.; George N. Wolcott, Head, Department of Entomology and Juan L. Moreno, Research Assistant in Entomology, both from the Agricultural Experiment Station, Río Piedras, P. R.

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TABLE 1.—*Water received by each crop of sugarcane grown at the Colonia Juana Díaz, Santa Isabel, 1948–52*

Crop year[1]	Rainfall[2]	Overhead irrigation	Total quantity of water[3]
	Inches	*Inches*	*Inches*
1948–49	41.45	48.00	89.45
1949–50	35.93	41.00	76.93
1950–51	39.02	36.70	75.72
1951–52	31.19	37.30	68.49

[1] Means the period from July to the next June, or from one harvest to the next.
[2] Natural rainfall, as obtained by the Saurí pluviometer at Colonia Juana Díaz. All records courtesy of M. S. Baker, Luce & Co., Aguirre.
[3] Includes the natural rainfall plus the water received by the sugarcane when using the artificial method of the overhead irrigation.

Rainfall and Overhead Irrigation Water

Table 1 summarizes the quantity of water received by each crop of sugarcane grown at Hacienda Juana Díaz from the summer of 1948 through all seasons, up to the summer of 1952, a period during which four different crops were harvested. Both the water received via overhead irrigation and that as natural rainfall are included.

MATERIALS AND METHODS

Overhead Irrigation for Spraying

The use of overhead irrigation makes possible the application of fertilizers dissolved in water, and of insecticides for the control of white grubs and other soil-insect pests of sugarcane.

When the purchase of an airplane for the application of insecticides to control the sugarcane moth stalk-borer was being considered, it seemed desirable to determine whether any of these insecticides would be effective during the Puerto Rican long-crop season, if applied by means of overhead irrigation. In the late winter of 1950, G. N. Wolcott[4] was requested to prepare a scheme of procedure to include all the new insecticides which might be of possible value, but by the time they had been purchased, the crop season was so far advanced as to make their application inadvisable at that time. By postponing the initiation of the tests until September 1950, it was possible to use cane which had just begun to form stalks and had a maximum development of leaf surface to receive the insecticides.

By starting the sprayings in September or October, the results of the effectiveness of the insecticides could be determined at the time of harvesting by examining the base of the stalks which developed and were

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subject to borer infestation when the insecticides were applied. It was not anticipated that the upper portions of the stalks developing from mid-November to the end of the crop season, would be affected by the insecticides, although it might be possible for the lag in subsequent infestation to take some time.

During 1950 the sprayings were scheduled as follows: The first, September 26–27; the second, October 13–14; the third, October 30–31; and the fourth and last, November 14–15.

During 1951, when the experiment was repeated, the sprayings were scheduled as follows: The first, October 16–17; the second, October 30–31; the third, November 13; and the fourth and last, November 27–28.

The applications of the insecticides took more time than was anticipated. Theoretically, if one revolution of the nozzle of the towers required only 10 minutes, the application of 10 insecticides at 2 strengths should not take all night. Actually, the delay involved in opening and closing the valves and changing the nozzles, and in applying an equal quantity of water to the checks, extended the time for making the tests from shortly after sunset until after sunrise of the next day. Frequently the full moon brilliantly illuminated the scene during the spraying operations; at other times the night was dark as a cave. During dark nights one could observe the intermittent flashes from the lighthouse on the offshore Island of Caja de Muertos. Those present during the spraying operations, besides the writers, were G. N. Wolcott, Mario Pérez[5], field assistants Juan Zambrana and Wilfredo Cruz, and laborers in charge of operating the towers.

Insecticides Used

The original plan called for tests with 12 insecticides, but DDT and Dilan, made by the Commercial Solvents Corp., were not available when the tests began. Those actually used in the 1950 experiment were Aldrin, Chlordane, Dieldrin, Ryania, Gy-phene, CPR Emulsion Concentrate, Marlate (methoxychlor), Rhothane, benzene hexachloride, and Kryocide. In the 1951 experiment the same insecticides were used with the exception of Dilan, Heptachlor 2E Emulsion, and Dr. Wolf's Insecticide which were substituted for Dieldrin and CPR Emulsion Concentrate (see table 2).

The concentration of insecticides or rate used per acre, as well as number of towers on which they were applied are presented in table 2.

The insecticides used during these tests may be described as follows: Hyman 118 or Aldrin, a product of Julius Hyman & Co., of Denver, Colo., known as Octalene, 24-percent emulsifiable concentrate, contained 2 pounds

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TABLE 2.—*Insecticides used at indicated towers and rates of application, 1950–51*

Insecticide	1950			1951		
	Tower No.	Rate of application		Tower No.	Rate of application	
		Insecticide per tower	Technical compound per acre		Insecticide per tower	Technical compound per acre
			Pounds			*Pounds*
Aldrin	11	1¼ gal.	1	22	1¼ gal.	1
Do.	12	2½ gal.	2	21	2½ gal.	2
Chlordane	5	3.25 lb.	1	26	3.25 lb.	1
Do.	6	6.50 lb.	2	25	6.50 lb.	2
Dieldrin	3	1¼ gal.	1	29[1]	1 gal. per 2½ A.	
Do.	2	2½ gal.	2	30[2]	1 gal. per 2½ A.	
Ryania	7	5 lb.	2	17	5 lb.	2
Do.	8	2½ lb.	1	18	2½ lb.	1
Rhothane	25	10 lb.	2	7	10 lb.	2
Do.	26	5 lb.	1	8	5 lb.	1
BHC	29	2½ gal.	1	2	2½ gal.	1
Do.	30	5 gal.	2	3	5 gal.	2
CPR	21	1¼ gal. per 2½ A.		13[3]	1 gal. per 2½ A.	
Do.	22	¾ gal. per 2½ A.		19	1½ gal. per 2½ A.	
Gy-phene	23	½ of ⅚ gal.	1	11	½ of ⅚ gal.	1
Do.	24	⅚ gal.	2	12	⅚ gal.	2
Marlate	17	10 lb.	2	6	10 lb.	2
Do.	18	5 lb.	1	5	5 lb.	1
Kryocide	19	25 lb.	10	24	25 lb.	10
Do.	13	15 lb.	6	23	15 lb.	6

[1] Dilan was used through this tower.
[2] Heptachlor was the insecticide used through this tower.
[3] Dr. Wolf's Insecticide was used instead of CPR used in 1950.

of the technical Hyman 118 per gallon. It was applied at rates of 1 and 2 pounds of the technical compound per acre.

Chlordan or Chlordane, a product of Julius Hyman & Co., 74-percent emulsifiable concentrate, contained 8 pounds of technical Chlordane per gallon. It was applied at rates of 1 and 2 pounds of the technical compound per acre.

Dieldrin or Hyman 497, also a product of Julius Hyman & Co., known as Octalox, was a 24-percent emulsifiable concentrate, containing 2 pounds of

technical Hyman 497 per gallon. It was applied at rates of 1 and 2 pounds of the technical compound per acre.

Ryania is the product obtained from the dried and powdered root of a tropical plant (*Ryania speciosa*), and was obtained from S. B. Pennick & Co., New York, N. Y., as Ryania powder, 100-percent pure for the 1950 tests, and as "Ryanicide 100", 100-percent purity, from the same manufacturer for the 1951 tests. The insecticide was used at rates of 1 and 2 pounds of the pure powder per acre.

Rhothane or DDD, was an analogue of DDT, manufactured by Rhom & Hass, Philadelphia, Pa., was obtained as a wettable powder, 50-percent concentrate, and was used at the rate of 1 and 2 pounds of the technical DDD per acre.

Benzene hexachloride or BHC was used as a concentrated emulsion; it was manufactured by the Pennsalt International Corp., Philadelphia, Pa., under the trade name of E-11, BHC Emulsion, containing 1 pound of the gamma isomer of BHC per gallon. The insecticide was applied at rates of 1 and 2 pounds of the gamma isomer per acre.

CPR emulsion concentrate, or CPR emulsifiable liquid concentrate, was manufactured by the Robert O. White Co., 1000 East Mermaid Lane, Philadelphia, Pa., and contained about 2 percent of piperonyl cyclonene, 0.20 percent of pyrethrins, and 1 percent of rotenone. It was used at rates of ¾ gallon and 1.25 gallons per 2½ acres.

Dr. Wolf's Insecticide A was used during the 1951 program as a substitute for CPR emulsion concentrate. This insecticide was based on the same active ingredients as CPR. It contained 2.12 percent of technical piperonyl cyclonene, 0.21 percent of pyrethrins, 1.06 percent of rotenone, and 2.12 percent of other cube resins as the most active ingredients. The product was manufactured by Dr. Wolf's Agricultural Laboratories, Bridgetown, N. J. It was used at rates of 1 gallon and 1½ gallons per 2½ acres.

Gy-phene E-60, concentrated emulsion, contained 6 pounds of technical Toxaphene per gallon. It was a product of Geigy Co. Inc., 89 Barclay St., New York, N. Y. It was used at rates of 1 and 2 pounds of technical toxaphene per acre.

Marlate was a Dupont product containing methoxychlor, a 50-percent wettable powder, and was used at rates of 1 and 2 pounds of the technical methoxychlor per acre.

Kryocide, a product of the Pennsalt International Corp., at Philadelphia, Pa., was a natural cryolite insecticide containing no less than 90-percent of sodium fluoaluminate. This insecticide was used at rates of 6 and 10 pounds per acre.

Heptachlor 2E Emulsion Concentrate, containing 2 pounds of the technical compound per gallon, was manufactured by the Velsicol Corp.,

Chicago, Ill. This product was used in one of the towers as a substitute for Dieldrin during the 1951 tests. The insecticide was applied at a rate of 1 gallon per 2½ acres.

Dilan 25 EM was used in one of the towers in substitution for Dieldrin during the 1951 tests. A product of Commercial Solvents Corp., New York, N. Y., it had the following formula:

	Percent
2-nitro-1,1-bis (p-chlorophenyl) propane (technical)	8.33[1]
2-nitro-1,1-bis (p-chlorophenyl) butane (technical)	16.67
Inert ingredients:	
Pine oil	70.00
Emulsifier	5.00

[1] Sample No. 50-1064, for experimental use, prepared by Commercial Solvents Corp.

These compounds are referred to in all tables as follows:

Aldrin	CPR
Chlordane	Dr. Wolf's Insecticide
Dieldrin	Gy-phene
Ryania	Marlate
Rhothane	Kryocide
BHC	Heptachlor
	Dilan

Procedure in Spraying Operations

The required quantities of the nine liquid insecticides as well as the four wettable powders were mixed with 6 gallons of water inside a metal barrel. The solution or suspension formed by mixing the insecticide was constantly stirred during the spraying operations. The barrel was connected directly to the main pump of the overhead irrigation system by means of a rubber hose. The diluted insecticide was mixed with the water of irrigation as it passed through the main pump. Since the tower took about 10 minutes to complete one revolution, the same time was taken to pour the total contents of the barrel through the main pipe, so that the insecticide was as evenly distributed as possible over the field to which it was applied.

There was a valve between the barrel and the rubber hose attached to the main pump. The partial opening and closing of the valve controlled the intake of insecticide from the barrel to the main pump. After practicing several times with plain water the valve was opened in such a way as to let a certain amount of insecticide in solution flow constantly and evenly

into the main pump. The distribution of the insecticide was timed so that the last of it was flowing out of the barrel when one tower had just finished its revolution and before another one started working. Figures 1 and 2 show one of the nozzles used and an irrigation tower in operation with nozzle attached.

It is surprising how promptly these insecticides could be detected by smell even when diluted in several hundreds of gallons of water. It was possible to recognize the agreeable odor of Chlordane, Aldrin, Dieldrin, and CPR in dilution, and of course also, the disagreeable odor of BHC.

Usually after one tower was used for spraying an insecticide, the next following was a check in which plain water was used. To give the fieldmen in charge of changing the nozzles on the towers enough time for their operations, each was worked for 20 minutes. During the first 10 minutes water only was sprayed, but during the last 10 minutes the insecticide was distributed, thus a whole revolution of the nozzle was completed during the period in which the insecticide was distributed. If the next tower was also to be used in the application of an insecticide, a 10-minute interval followed to prepare the next insecticide in solution and place it in the barrel ready for distribution. If the tower following was a check tower, there were 30 minutes to wait until the next application, that is, 20 minutes for the check, 10 minutes of spare time, and then the application of the insecticide began on the last 10 minutes of the tower in operation. In this way each area irrigated by the towers received 20 minutes of artificial rainfall, regardless of whether it was a check or had received a treatment of insecticide. These were the factors which consumed so much time in the distribution of the insecticides through the overhead irrigation system.

The spraying operations were scheduled to take place with an interval of 15 days between applications, and four applications were given in each experiment during 1950 and 1951.

Sugarcane Stalk Moth-Borer Counts

When the sugarcane was harvested in the overhead irrigation area a random sample of 100 canes was taken from around each tower, with precautions not to take samples from adjoining areas or from the areas covered by other towers. The stalks were examined, the joints counted, and the percentage of moth-borer infestation was determined. Tables 3 and 4 show the percentage of infestation in the overhead irrigation area during the 1951 and 1952 crops corresponding to the period of application of insecticides during the autumns of 1950 and 1951, respectively.

RESULTS AND ANALYSIS

The results of the tests are shown in tables 3 for 1951 and 4 for 1952. Although the last sections of each table should be taken into consideration

FIG. 1.—Workman carrying the nozzle to one of the irrigation towers. Only 2 nozzles were used to operate 31 of the towers. The larger outlet is designed to irrigate 90 percent of the area around the tower and the smaller to irrigate the area in close proximity to the tower.

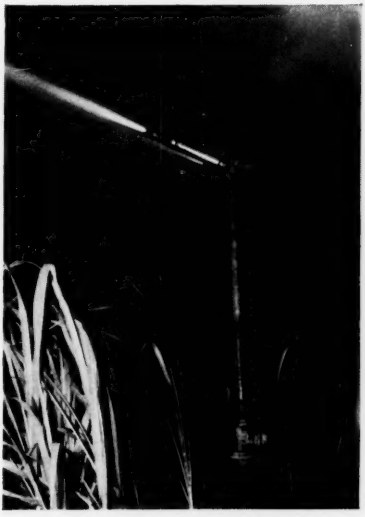

FIG. 2.—One of the irrigation towers in operation after the nozzle had been attached.

TABLE 3.—*Rate of infestation by* ***Diatraea saccharalis*** *(Fabricius) at overhead irrigation area, Colonia Juana Díaz, Santa Isabel, 1951*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage stalk infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
30	P.O.J. 2878	BHC, 2 lb. gamma isomer per A.	7	0.74	0.05	0.05	0.63
20	B.H. 10(12)	Check	11	.927	.040	.282	.604
24	P.O.J. 2878	Gy-phene, 2 lb. Toxaphene (tech.) per A.	16	1.96	.05	.53	1.37
31	P.O.J. 2878	Check	20	1.54	.06	.45	1.02
25	P.O.J. 2878	Rothane, 2 lb. DDD (tech.) per A.	21	2.04	.05	.76	1.22
27	P.O.J. 2878	Check	24	1.97	.49	.71	.77
26	P.O.J. 2878	Rothane, 1 lb. DDD (tech.) per A.	27	3.22	.11	.52	2.58
18	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	29	3.08	.27	1.68	1.13
19	B.H. 10(12)	Kryocide, 10 lb. per A.	29	3.11	.31	1.02	1.77
15	B. 34-104	Check	33	3.33	.35	.35	2.63
23	P.O.J. 2878	Gy-phene, 1 lb. of Toxaphene (tech.) per A.	33	4.02	.35	.71	2.95
28	P.R. 902	Check	33	2.19	.22	.92	1.05
29	P.R. 902	BHC, 1 lb. gamma isomer per A.	33	3.07	.17	.81	2.09
9	P.O.J. 2878	Check	34	4.73	.37	.69	3.66
16	P.O.J. 2878	do.	34	4.54	.27	.83	3.43
22	P.O.J. 2878	CPR, ¾ gal. on 2½ A.	38	3.68	.35	1.06	2.26
14	B.H. 10(12)	Check	40	3.95	.15	1.28	2.52
10	B.H. 10(12)	do.	46	5.20	.54	1.28	3.37
21	P.R. 902	CPR, 1¼ gal. on 2½ A.	52	5.48	.40	1.24	3.83
1	B.H. 10(12)	Check	53	4.93	.86	1.17	2.90
13	B.H. 10(12)	Kryocide, 6 lb. per A.	54	5.78	.17	1.76	3.84
17	P.O.J. 2878 B.H. 10(12)	Marlate, 2 lb. Methoxychlor per A.	57	8.15	.37	3.03	4.74
7	P.O.J. 2878 B.H. 10(12)	Ryania, 2 lb. per A.	71	11.73	1.13	2.69	7.90
8	P.O.J. 2878	Ryania, 1 lb. per A.	72	10.82	1.37	3.11	6.33
11	B.H. 10(12)	Aldrin, 1 lb. Aldrin (tech.) per A.	75	11.84	1.54	4.72	5.57
4	B.H. 10(12)	Check	80	12.70	1.11	4.77	6.81
12	B.H. 10(12)	Aldrin, 2 lb. Aldrin (tech.) per A.	84	13.15	.92	5.50	6.72
5	B.H. 10(12)	Chlordane, 3.25 lb Chlordane (tech.) on 2½ A.	93	20.44	1.49	6.92	12.02

TABLE 3.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
In ascending order based on percentage stalk infestation							
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
3	B.H. 10(12)	Dieldrin, 1 lb. Dieldrin (tech.) per A.	96	26.07	.73	10.80	14.54
6	P.O.J. 2878 B.H. 10(12)	Chlordane, 6.50 lb. Chlordane (tech.) on 2½ A.	96	21.75	1.73	6.81	13.20
2	B.H. 10(12)	Dieldrin, 2 lb. Dieldrin (tech.) per A.	98	27.72	3.49	11.25	12.97
In ascending order based on percentage joint infestation							
30	P.O.J. 2878	BHC, 2 lb. gamma isomer per A.	7	0.74	0.05	0.05	0.63
20	B.H. 10(12)	Check	11	.927	.040	.282	.604
31	P.O.J. 2878	do.	20	1.54	.06	.45	1.02
24	P.O.J. 2878	Gy-phene, 2 lb. Toxaphene (tech.) per A.	16	1.96	.05	.53	1.37
27	P.O.J. 2878	Check	24	1.97	.49	.71	.77
25	P.O.J. 2878	Rhothane, 2 lb. DDD (tech.) per A.	21	2.04	.05	.76	1.22
28	P.R. 902	Check	33	2.19	.22	.92	1.05
29	P.R. 902	BHC, 1 lb. gamma isomer per A.	33	3.07	.17	.81	2.09
18	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	29	3.08	.27	1.68	1.13
19	B.H. 10(12)	Kryocide, 10 lb. per A.	29	3.11	.31	1.02	1.77
26	P.O.J. 2878	Rhothane, 1 lb. DDD (tech.) per A.	27	3.22	.11	.52	2.58
15	B. 34-104	Check	33	3.33	.35	.35	2.63
22	P.O.J. 2878	CPR, ¾ gal. on 2½ A.	38	3.68	.35	1.06	2.26
14	B.H. 10(12)	Check	40	3.95	.15	1.28	2.52
23	P.O.J. 2878	Gy-phene, 1 lb. Toxaphene (tech.) per A.	33	4.02	.35	.71	2.95
16	P.O.J. 2878	Check	34	4.54	.27	.83	3.43
9	P.O.J. 2878	do.	34	4.73	.37	.69	3.66
1	B.H. 10(12)	do.	53	4.93	.86	1.17	2.90
10	B.H. 10(12)	do.	46	5.20	.54	1.28	3.37
21	P.R. 902	CPR, 1¼ gal. on 2½ A.	52	5.48	.40	1.24	3.83
13	B.H. 10(12)	Kryocide, 6 lb. per A.	54	5.78	.17	1.76	3.84
17	P.O.J. 2878 B.H. 10(12)	Marlate, 2 lb. Methoxychlor (tech.) per A.	57	8.15	.37	3.03	4.74
8	P.O.J. 2878	Ryania, 1 lb. per A.	72	10.82	1.37	3.11	6.33
7	P.O.J. 2878	Ryania, 2 lb. per A.	71	11.73	1.13	2.69	7.90

TABLE 3.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage joint infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
11	B.H. 10(12)	Aldrin, 1 lb. Aldrin (tech.) per A.	75	11.84	1.54	4.72	5.57
4	B.H. 10(12)	Check	80	12.70	1.11	4.77	6.81
12	B.H. 10(12)	Aldrin, 2 lb. Aldrin (tech.) per A.	84	13.15	.92	5.50	6.72
5	B.H. 10(12)	Chlordane, 3.25 lb. Chlordane (tech.) on 2½ A.	93	20.44	1.49	6.92	12.02
6	P.O.J. 2878 B.H. 10(12)	Chlordane, 6.50 lb. Chlordane (tech.) on 2½ A.	92	21.75	1.73	6.81	13.20
3	B.H. 10(12)	Dieldrin, 1 lb. Dieldrin (tech.) per A.	96	26.07	.73	10.80	14.54
2	B.H. 10(12)	Dieldrin, 2 lb. Dieldrin (tech.) per A.	98	27.72	3.49	11.25	12.97
		In ascending order based on percentage base infestation					
20	B.H. 10(12)	Check	11	0.927	0.040	0.282	0.604
24	P.O.J. 2878	Gy-phene, 2 lb. Toxaphene (tech.) per A.	16	1.96	.05	.53	1.37
25	P.O.J. 2878	Rhothane, 2 lb. DDD (tech.) per A.	21	2.04	.05	.76	1.22
30	P.O.J. 2878	BHC, 2 lb. gamma isomer per A.	7	.74	.05	.05	.63
31	P.O.J. 2878	Check	20	1.54	.06	.45	1.02
26	P.O.J. 2878	Rhothane, 1 lb. DDD (tech.) per A.	27	3.22	.11	.52	2.58
14	B.H. 10(12)	Check	40	3.95	.15	1.28	2.52
13	B.H. 10(12)	Kryocide, 6 lb. per A.	54	5.78	.17	1.76	3.84
29	P.R. 902	BHC, 1 lb. gamma isomer per A.	33	3.07	.17	.81	2.09
28	P.R. 902	Check	33	2.19	.22	.92	1.05
16	P.O.J. 2878	Check	34	4.54	.27	.83	3.43
18	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	29	3.08	.27	1.68	1.13
19	B.H. 10(12)	Kryocide, 10 lb. per A.	29	3.11	.31	1.02	1.77
15	B. 34-104	Check	33	3.33	.35	.35	2.63
22	P.O.J. 2878	CPR, ¾ gal. on 2½ A.	38	3.68	.35	1.06	2.26
23	P.O.J. 2878	Gy-phene, 1 lb. Toxaphene (tech.) per A.	33	4.02	.35	.71	2.95
9	P.O.J. 2878	Check	34	4.73	.37	.69	3.66
17	P.O.J. 2878 B.H. 10(12)	Marlate, 2 lb. Methoxychlor (tech.) per A.	57	8.15	.37	3.03	4.74
21	P.R. 902	CPR, 1¼ gal. on 2½ A.	52	5.48	.40	1.24	3.83
27	P.O.J. 2878	Check	24	1.97	.49	.71	.77
10	B.H. 10(12)	do.	46	5.20	.54	1.28	3.37

TABLE 3.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage base infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
3	B.H. 10(12)	Dieldrin, 1 lb. Dieldrin (tech.) per A.	96	26.07	.73	10.80	14.54
1	B.H. 10(12)	Check	53	4.93	.86	1.17	2.90
12	B.H. 10(12)	Aldrin, 2 lb. Aldrin, (tech) per A.	84	13.15	.92	5.50	6.72
4	B.H. 10(12)	Check	80	12.70	1.11	4.77	6.81
7	P.O.J. 2878 B.H. 10(12)	Ryania, 2 lb. per A.	71	11.73	1.13	2.69	7.90
8	P.O.J. 2878	Ryania, 1 lb. per A.	72	10.82	1.37	3.11	6.33
5	B.H. 10(12)	Chlordane, 3.25 lb. Chlordane (tech.) per A.	93	20.44	1.49	6.92	12.02
11	B.H. 10(12)	Aldrin, 1 lb. Aldrin (tech.) per A.	75	11.84	1.54	4.72	5.57
6	P.O.J. 2878 B.H. 10(12)	Chlordane, 6.50 lb. Chlordane (tech.) on 2½ A.	96	21.75	1.73	6.81	13.20
2	B.H. 10(12)	Dieldrin, 2 lb. Dieldrin (tech.) per A.	98	27.72	3.49	11.25	12.97

in the main in analyzing the results of the tests on the effectiveness of the insecticides tested, other data have been included for both years to demonstrate how the percentages of joint and stalk infestation are affected by the action of the insecticides.

The results in tables 3 and 4 are expressed in ascending order of borer infestation, that is: from the lowest infestation found near any of the towers, followed by the next highest, and so on, until the highest infestation is reached at the end of the table. For this study the cane stalk was divided into three sections: Top, center, and base. The percentage of borer infestation was determined for all three, as well as for the joint and stalk in each plot. The figures for the infestation in the center and top of the stalks are not included, since they have no bearing on the experiment.

As mentioned earlier, the data on base infestation are of most importance. The insecticides were applied during the period of growth of the lower or basal section of the stalk, known as the base. Thus, control of the borer was estimated to cover that period, and if any insecticides proved effective, that period of protection by the insecticide was longer or shorter, depending upon its residual properties, if any.

To check on the effectiveness of the insecticides in the control of the

TABLE 4.—*Rate of infestation by* ***Diatraea saccharalis*** *(Fabricius) at overhead irrigation area, Colonia Juana Díaz, Santa Isabel, 1952*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage stalk infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
4	B.H. 10(12)	Check	18	2.33	0.38	1.71	0.24
1	B.H. 10(12)	do.	37	3.39	.27	2.26	.86
5	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	49	5.43	1.19	2.10	2.14
27	P.O.J. 2878	Check	50	7.74	.34	2.58	4.82
2	B.H. 10(12)	BHC, 1 lb. gamma isomer per A.	51	5.59	1.18	2.68	1.73
18	P.O.J. 2878	Ryania, 1 lb. per A.	53	6.25	.45	2.99	2.80
10	B.H. 10(12)	Check	60	6.95	.38	2.03	4.54
16	P.O.J. 2878	do.	61	8.38	.14	2.46	5.78
24	B.H. 10(12)	Kryocide, 10 lb. per A.	61	9.45	.67	3.72	5.06
29	P.R. 902	Dilan, 1 gal. on 2½ A.	63	7.50	.27	1.71	5.51
7	P.O.J. 2878 B.H. 10(12)	Rhothane 2 lb. DDD (tech.) per A.	65	8.09	.94	3.08	4.07
23	P.O.J. 2878	Kryocide, 6 lb. per A.	65	10.35	.55	2.62	7.17
14	B.H. 10(12)	Check	69	10.51	1.01	4.76	4.73
17	P.O.J. 2878 B.H. 10(12)	Ryania, 2 lb. per A.	69	9.45	.81	5.69	2.95
19	B.H. 10(12)	Dr. Wolf's Insecticide, 1½ gal. on 2½ A.	74	12.61	1.31	7.84	3.46
8	P.O.J. 2878	Rhothane, 1 lb. DDD (tech.) per A.	76	15.95	1.30	8.00	6.65
15	B. 34-104	Check	77	11.96	.38	6.24	5.33
13	P.O.J. 2878	Dr. Wolf's Insecticide, 1 gal. on 2½ A.	79	10.92	.87	5.86	4.18
9	P.O.J. 2878	Check	80	14.93	.83	7.39	6.71
12	B.H. 10(12)	Gy-phene, 2 lb. Toxaphene (tech.) per A.	83	13.90	3.10	8.34	2.46
3	B.H. 10(12)	BHC, 2 lb. gamma isomer per A.	85	9.17	1.36	5.42	2.39
6	P.O.J. 2878 B.H. 10(12)	Marlate, 2 lb. Methoxychlor (tech.) per A.	88	12.49	2.14	5.53	4.81
20	B.H. 10(12)	Check	88	15.89	1.98	8.71	5.20
11	B.H. 10(12)	Gy-phene, 1 lb. Toxaphene (Tech.) per A.	89	15.85	2.51	9.58	3.76
28	P.R. 902	Check	89	15.97	1.17	7.04	7.76
22	P.O.J. 2878	Aldrin, 1 lb. Aldrin (tech.) per A.	90	13.69	.52	8.00	5.16
30	P.O.J. 2878	Heptachlor, 1 gal. on 2½ A.	91	20.36	.76	7.82	11.78
26	P.O.J. 2878	Chlordane, 1 lb. Chlordane (tech.) per A.	92	20.82	2.66	11.32	6.84

TABLE 4.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage stalk infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
21	P.R. 902	Aldrin, 2 lb. Aldrin (tech.) per A.	94	19.66	.59	9.32	9.75
25	P.O.J. 2878	Chlordane, 2 lb. Chlordane (tech.) per A.	97	24.43	1.03	12.24	11.16
31	P.O.J. 2878	Check	97	23.33	2.46	13.22	7.65
		In ascending order based on percentage joint infestation					
4	B.H. 10(12)	Check	18	2.33	0.38	1.71	0.24
1	B.H. 10(12)	do.	37	3.39	.27	2.26	.86
5	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	49	5.43	1.19	2.10	2.14
2	B.H. 10(12)	BHC, 1 lb. gamma isomer per A.	51	5.59	1.18	2.68	1.73
18	P.O.J. 2878	Ryania, 1 lb. per A.	53	6.25	.45	2.99	2.80
10	B.H. 10(12)	Check	60	6.95	.38	2.03	4.54
29	P.R. 902	Dilan, 1 gal. on 2½ A.	63	7.50	.27	1.71	5.51
27	P.O.J. 2878	Check	50	7.74	.34	2.58	4.82
7	P.O.J. 2878 B.H. 10(12)	Rhothane, 2 lb. DDD (tech.) per A.	65	8.09	.94	3.08	4.07
16	P.O.J. 2878	Check	61	8.38	.14	2.46	5.78
3	B.H. 10(12)	BHC, 2 lb. gamma isomer per A.	85	9.17	1.36	5.42	2.39
17	P.O.J. 2878 B.H. 10(12)	Ryania, 2 lb. per A.	69	9.45	.81	5.69	2.95
24	B.H. 10(12)	Kryocide, 10 lb. per A.	61	9.45	.67	3.72	5.06
23	P.O.J. 2878	Kryocide, 6 lb. per A.	65	10.35	.55	2.62	7.17
14	B.H. 10(12)	Check	69	10.51	1.01	4.76	4.73
13	P.O.J. 2878	Dr. Wolf's Insecticide, 1 gal. on 2½ A.	79	10.92	.87	5.86	4.18
15	B. 34-104	Check	77	11.96	.38	6.24	5.33
6	B.H. 10(12) P.O.J. 2878	Marlate, 1 lb. Methoxychlor (tech.) per A.	88	12.49	2.14	5.53	4.81
19	B.H. 10(12)	Dr. Wolf's Insecticide, 1½ gal. on 2½ A.	74	12.61	1.31	7.84	3.46
22	P.O.J. 2878	Aldrin, 1 lb. Aldrin (tech.) per A.	90	13.69	.52	8.00	5.16
12	B.H. 10(12)	Gy-phene, 2 lb. Toxaphene (tech.) per A.	83	13.90	3.10	8.34	2.46

TABLE 4.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage joint infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
9	P.O.J. 2878	Check	80	14.93	.83	7.39	6.71
11	B.H. 10(12)	Gy-phene, 1 lb. Toxaphene (tech.) per A.	89	15.85	2.51	9.58	3.76
20	B.H. 10(12)	Check	88	15.89	1.98	8.71	5.20
8	P.O.J. 2878	Rhothane, 1 lb. DDD (tech.) per A.	76	15.95	1.30	8.00	6.65
28	P.R. 902	Check	89	15.97	1.17	7.04	7.76
21	P.R. 902	Aldrin, 2 lb. Aldrin (tech.) per A.	94	19.66	.59	9.32	9.75
30	P.O.J. 2878	Heptachlor, 1 gal. on 2½ A.	91	20.36	.76	7.82	11.78
26	P.O.J. 2878	Chlordane, 1 lb. Chlordane (tech.) per A.	92	20.82	2.66	11.32	6.84
31	P.O.J. 2878	Check	97	23.33	2.46	13.22	7.65
25	P.O.J. 2878	Chlordane, 2 lb. Chlordane (tech.) per A.	92	24.43	1.03	12.24	11.16
		In ascending order based on percentage base infestation					
16	P.O.J. 2878	Check	61	8.38	0.14	2.46	5.78
1	B.H. 10(12)	do.	37	3.39	.27	2.26	.86
29	P.R. 902	Dilan, 1 gal .on 2½ A.	63	7.50	.27	1.71	5.51
27	P.O.J. 2878	Check	50	7.74	.34	2.58	4.82
4	B.H. 10(12)	do.	18	2.33	.38	1.71	.24
10	B.H. 10(12)	do.	60	6.95	.38	2.03	4.54
15	B. 34-104	do.	77	11.96	.38	6.24	5.33
18	P.O.J. 2878	Ryania, 1 lb. per A.	53	6.25	.45	2.99	2.80
22	P.O.J. 2878	Aldrin, 1 lb. Aldrin (tech.) per A.	90	13.69	.52	8.00	5.16
23	P.O.J. 2878	Kryocide, 6 lb. per A.	65	10.35	.55	2.62	7.17
21	P.R. 902	Aldrin, 2 lb. Aldrin (tech.) per A.	94	19.66	.59	9.32	9.75
24	B.H. 10(12)	Kryocide, 10 lb. per A.	61	9.45	.67	3.72	5.06
30	P.O.J. 2878	Heptachlor, 1 gal. on 2½ A.	91	20.36	.76	7.82	11.78
17	P.O.J. 2878 B.H. 10(12)	Ryania, 2 lb. per A.	69	9.45	.81	5.69	2.95
9	P.O.J. 2878	Check	80	14.93	.83	7.39	6.71
13	P.O.J. 2878	Dr. Wolf's Insecticide, 1 gal. on 2½ A.	79	10.92	.87	5.86	4.18
7	P.O.J. 2878 B.H. 10(12)	Rhothane, 2 lb. DDD (tech.) per A.	65	8.09	.94	3.08	4.07

TABLE 4.—*Continued*

Tower No.	Sugarcane variety	Treatment	Stalk infestation	Joint infestation	Base infestation	Center infestation	Top infestation
		In ascending order based on percentage base infestation					
			Percent	*Percent*	*Percent*	*Percent*	*Percent*
14	B.H. 10(12)	Check	69	10.51	1.01	4.76	4.73
25	P.O.J. 2878	Chlordane, 2 lb. Chlordane (tech.) per A.	97	24.43	1.03	12.24	11.16
28	P.R. 902	Check	89	15.97	1.17	7.04	7.76
2	B.H. 10(12)	BHC, 1 lb. gamma isomer per A.	51	5.59	1.18	2.68	1.73
5	B.H. 10(12)	Marlate, 1 lb. Methoxychlor (tech.) per A.	49	5.43	1.19	2.10	2.14
8	P.O.J. 2878	Rhothane, 1 lb. DDD (tech.) per A.	76	15.95	1.30	8.00	6.65
19	B.H. 10(12)	Dr. Wolf's Insecticide, 1½ gal. on 2½ A.	74	12.61	1.31	7.84	3.46
3	B.H. 10(12)	BHC, 2 lb. gamma isomer per A.	85	9.17	1.36	5.42	2.39
20	B.H. 10(12)	Check	88	15.89	1.98	8.71	5.20
6	P.O.J. 2878 B.H. 10(12)	Marlate, 2 lb. Methoxychlor (tech.) per A.	88	12.49	2.14	5.53	4.81
31	P.O.J. 2878	Check	97	23.33	2.46	13.22	7.65
11	B.H. 10(12)	Gy-phene, 1 lb. Toxaphene (tech.) per A.	89	15.85	2.51	9.58	3.76
26	P.O.J. 2878	Chlordane, 1 lb. Chlordane (tech.) per A.	92	20.82	2.66	11.32	6.84
12	B.H. 10(12)	Gy-phene, 2 lb. Toxaphene (tech.) per A.	83	13.90	3.10	8.34	2.46

borer, they were shifted from one tower to another far from it, in the 1950–51 sprayings. The check plots were the same for both years.

Partial results of tables 3 and 4 for 1951–52 are summarized in tables 5 and 6. In these tables the percentage of moth-borer infestation at the base of the cane is shown in order of ascending infestation for the 10 plots having the lowest infestation. The figures for ascending infestation for the 10 lowest plots are also given in addition, based on joints and stalks bored.

Base Infestation

In the 1951 crop, the plot showing the lowest base infestation was a check (tower 20) followed by one on which 2 pounds per acre of Gy-phene were used, (tower 24) etc., as shown in table 5. It will be noticed that 4 check plots are included in these 10 plots having lowest base infestation.

In the 1952 crop, the two plots having the lowest base infestation were

TABLE 5.—*Rate of moth-borer infestation expressed as percentage of stalk, joint, and base, in ascending order of percentage infestation in plots sprayed by 10 towers, 1951–1952*

[Data extracted from tables 3 and 4]

1951			1952		
Tower No.	Insecticide and quantity	Infestation rate	Tower No.	Insecticide and quantity	Infestation rate
	Results with stalks				
		Percent			*Percent*
30	BHC, 2 lb. per A.	7	4	Check	18
20	Check	11	1	do.	37
24	Gy-phene, 2 lb. per A.	16	5	Marlate, 1 lb. per A.	49
31	Check	20	27	Check	50
25	Rhothane, 2 lb. per A.	21	2	BHC, 1 lb. per A.	51
27	Check	24	18	Ryania, 1 lb. per A.	53
26	Rhothane, 1 lb. per A.	27	10	Check	60
18	Marlate, 1 lb. per A.	29	16	do.	61
19	Kryocide, 10 lb. per A.	29	24	Kryocide, 10 lb. per A.	61
15	Check	33	29	Dilan, 1 gal. per 2½ A.	63
	Results with joints				
30	BHC, 2 lb. per A.	0.74	4	Check	2.33
20	Check	.93	1	do.	3.39
31	do.	1.54	5	Marlate, 1 lb. per A.	5.43
24	Gy-phene, 2 lb. per A.	1.96	2	BHC, 1 lb. per A.	5.59
27	Check	1.97	18	Ryania, 1 lb. per A.	6.25
25	Rhothane, 2 lb. per A.	2.04	10	Check	6.95
28	Check	2.19	29	Dilan, 1 gal. per 2½ A.	7.50
29	BHC, 1 lb. per A.	3.07	27	Check	7.74
18	Marlate, 1 lb. per A.	3.08	7	Rhothane, 2 lb. per A.	8.09
19	Kryocide, 10 lb. per A.	3.11	16	Check	8.38
	Results with bases				
20	Check	0.04	16	Check	0.14
24	Gy-phene, 2 lb. per A.	.05	1	do.	.27
25	Rhothane, 2 lb. per A.	.05	29	Dilan, 1 gal. per 2½ A.	.27
30	BHC, 2 lb. per A.	.05	27	Check	.34
31	Check	.06	4	do.	.38
26	Rhothane, 1 lb. per A.	.11	10	do.	.38
14	Check	.15	15	do.	.38
13	Kryocide, 6 lb. per A.	.17	18	Ryania, 1 lb. per A.	.45
29	BHC, 1 lb. per A.	.17	22	Aldrin, 1 lb. per A.	.52
28	Check	.22	23	Kryocide, 6 lb. per A.	.55

TABLE 6.—*Rate of moth-borer infestation based on attacks of the borer at the base of the cane, in ascending order of percentage infestation in plots sprayed by 10 towers, 1951–1952*

[Data extracted from tables 3 and 4]

1951 crop			1952 crop		
Tower No.	Insecticide and quantity	Infestation rate	Tower No.	Insecticide and quantity	Infestation rate
		Percent			*Percent*
20	Check	0.04	16	Check	0.14
24	Gy-phene, 2 lb per A.	.05	1	do.	.27
25	Rhothane, 2 lb. per A.	.05	29	Dilan, 1 gal. per 2½ A.	.27
30	BHC, 2 lb. per A.	.05	27	Check	.34
31	Check	.06	4	do.	.38
26	Rhothane, 1 lb. per A.	.11	10	do.	.38
14	Check	.15	15	do.	.38
13	Kryocide, 6 lb. per A.	.17	18	Ryania, 1 lb. per A.	.45
29	BHC, 1 lb. per A.	.17	22	Aldrin, 1 lb. per A.	.52
28	Check	.22	23	Kryocide, 6 lb. per A.	.55

also check plots (towers 16 and 1), followed by Dilan (tower 29), and then by four more check plots (towers 27, 4, 10, 15). This means that for this crop, 6 check plots were included in the 10 lowest plots insofar as base infestation by the borer was concerned.

This alone might lead to the conclusion that the insecticides were inef-

TABLE 7.—*Rate of moth-borer infestation based on attacks of the borer at the base of the cane, demonstrating the highest infestation in plots sprayed by 10 towers, 1951–52*

[Data extracted from tables 3 and 4]

1951 crop			1952 crop		
Tower No.	Insecticide and quantity	Percentage of base infestation	Tower No.	Insecticide and quantity	Percentage of base infestation
3	Dieldrin, 1 lb. per A.	0.73	5	Marlate, 1 lb. per A.	1.19
1	Check	.86	8	Rhothane, 1 lb. per A.	1.30
12	Aldrin, 2 lb. per A.	.92	19	Dr. Wolf's Insecticide 1½ gal. for 2½ A.	1.31
4	Check	1.11	3	BHC, 2 lb. per A.	1.36
7	Ryania, 2 lb. per A.	1.13	20	Check	1.98
8	Ryania, 1 lb. per A.	1.37	6	Marlate, 2 lb. per A.	2.14
5	Chlordane, 1 lb. per A.	1.49	31	Check	2.46
11	Aldrin, 1 lb. per A.	1.54	11	Gy-phene, 1 lb. per A.	2.51
6	Chlordane, 2 lb. per A.	1.73	26	Chlordane, 1 lb. per A	2.66
2	Dieldrin, 2 lb. per A.	3.49	12	Gy-phene, 2 lb. per A.	3.10

fective in the control of the borer. The check plots had only plain water as a spray, and yet they showed low borer infestation at the base of the stalk.

Suppose we assume that Gy-phene at a rate of 2 pounds per acre (tower 24) and Rhothane, at rates of 2 pounds and 1 pound per acre, respectively, (towers 25 and 26) were effective insecticides in the control of the borer because they top the list shown in table 5. Then the same effectiveness should have been demonstrated in the test for 1952. Yet the results were not the same, for Gy-phene applied to the 1952 crop at a rate of 2 pounds per acre by tower 12, showed the highest base infestation for the experiment that year (see table 7). Rhothane at rates of 2 pounds and 1 pound per acre, respectively, was sprayed through towers 7 and 8 during the 1952 crop

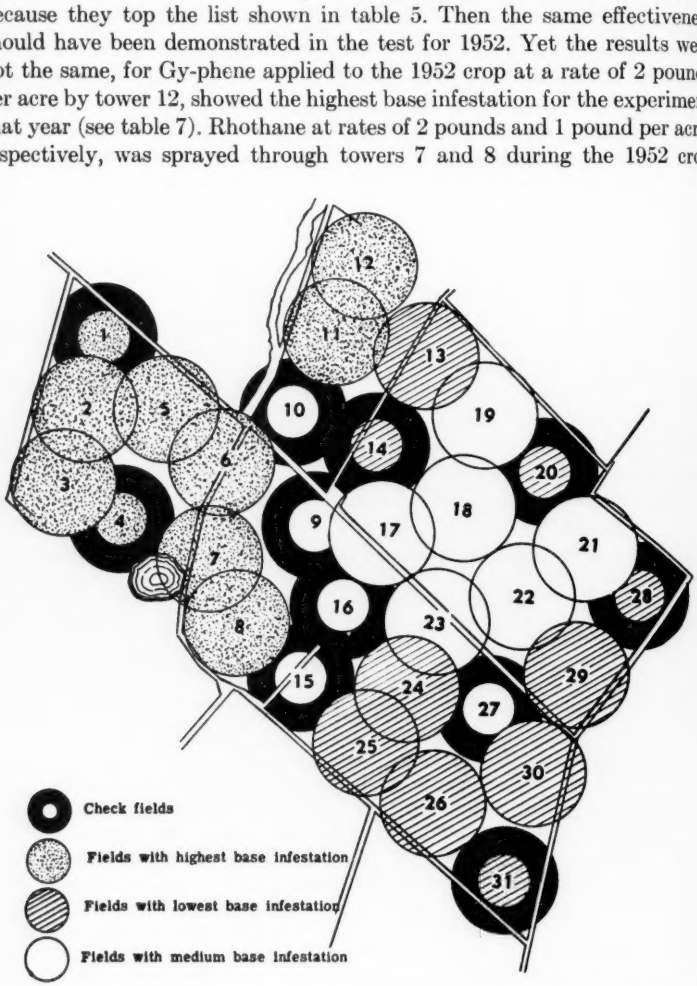

FIG. 3.—Location and infestation of plots under the overhead-irrigation area at Colonia Juana Diaz, 1951 crop.

season. The insecticide did not give the same results as in 1951, but was far down on the list for 1952, in the seventeenth and twenty-third place, respectively. If we continue to analyze the effects of the other insecticides we find much the same results.

Why should Kryocide applied at a rate of 6 pounds per acre through tower 13 for the 1951 crop be more effective than the same insecticide applied at a rate of 10 pounds per acre through tower 19 for the same crop? Then why should Ryania at a rate of 1 pound per acre, Aldrin at 1 pound per acre, and Kryocide at 6 pounds per acre, applied through towers 18, 22, and 23, respectively, for the 1952 crop, be more effective than the same insecticides at 2 pounds per acre, 2 pounds per acre, and 10 pounds per

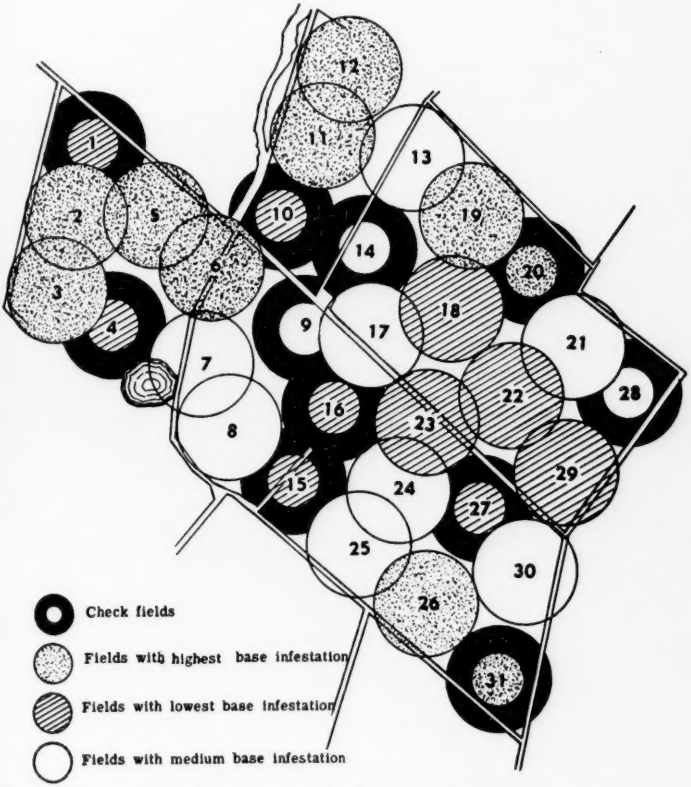

FIG. 4.—Location and infestation of plots under the overhead-irrigation area at Colonia Juana Diaz, 1952 crop.

acre, respectively, when applied elsewhere to the same crop? It is very illogical that the effectiveness of an insecticide should diminish when the quantity applied is doubled or nearly doubled. The reverse would be logical.

Table 7 shows the infestation by the moth-borer at the base of the stalks for the 10 worst infested plots in both years, 1951 and 1952. As shown, insecticides like Gy-phene, BHC, Rhothane, and Aldrin, which are on the list in table 6 as producing low base infestation are also found in the list for the highest infestation.

Everything tended to indicate that the moth-borer infestation in the overhead irrigation area is mostly a question of position of the plots. For example, examinations of figures 3 and 4, which show the results of the moth-borer infestation, discloses that plots Nos. 1, 2, 3, 4, 5, 7, 8, 11, and 12 were the ones with the highest base infestation. These plots are located at the west and northwest ends of the area. When this is compared with the results for the 1952 crop, it is obvious that plots Nos. 2, 3, 5, 6, 11, and 12 were also high in infestation regardless of the insecticides used. Apparently the infestation by the borer in the northwest and west sections of the overhead-irrigation area is practicaly uniform, year after year.

Table 8 shows the percentage of infestation by the sugarcane moth-borer a Colonia Juana Díaz as compared with the infestation in the overhead-irrigation area. Since 1949, the borer infestation has been on the increase in this particular zone in both the overhead-irrigation area and the rest of the Colonia where the cane is irrigated by gravity methods. This natural

TABLE 8.—*Sugarcane moth stalk-borer infestation at Colonia Juana Díaz, 1949-52*

Year	Fields	Percentage of sugarcane moth-borer infestation in cane fields outside of the overhead-irrigation area					Percentage of sugarcane moth-borer infestation in cane fields in the overhead-irrigation area				
		Top	Center	Base	Joint	Stalk	Top	Center	Base	Joint	Stalk
	Number										
1949	10	—	—	—	7.3	—	—	—	—	5.8	—
1950	38	4.30	2.64	2.06	9.01	65	3.28	2.68	1.61	7.57	57
	9[1]	4.44	2.33	2.43	9.20	67					
1951	37	4.36	2.66	1.46	8.49	58	5.18	3.68	.83	10.36[2]	54
	10[1]	3.38	1.60	1.04	6.03	46	2.75	1.26	.44	4.48[3]	37
1952	62	4.28	3.91	1.95	10.14	70	4.88	6.08	1.23	12.19[2]	76
	10[1]	4.50	4.43	2.70	11.63	76	4.65	5.12	.84	10.61[3]	66

[1] Fields around the overhead-irrigation area, but not irrigated with the overhead-irrigation system.

[2] Fields or area around towers which were sprayed with organic insecticides for the control of the sugarcane moth stalk-borer.

[3] Fields or area around towers which were sprayed with water only, and served as check plots.

increase of borers might be due to a decrease in precipitation (both natural and artificial, the latter as supplied by the overhead-irrigation system) from year to year, since 1949 up to 1952. Table 1 show sthese rainfall differences as well as amount of water received by the cane naturally and artificially.

Comparing the 20 sprayed plots in general with the 11 check plots, as shown in table 8, there was less base infestation in the latter than in the former. This is true for both 1950 and 1951, in which crop years the check plots showed 0.44-percent and 0.84-percent base infestation, respectively, vs. 0.83-percent and 1.23-percent base infestation for the sprayed plots for both years.

CONCLUSIONS

The following conclusions appear justified by the work here reported:

The application of insecticides by the overhead-irrigation system for the attempted control of the moth stalk-borer, *Diatraea saccharalis* (Fabricius) during 2-year tests at Central Cortada, reversing the position of the insecticides the second year, indicates that this method, successful as it may be for the application of fertilizers or the control of soil-inhabiting insects, is valueless against the moth-borer.

This may be due to the large amount of water which must be used for a single revolution of the tower, which so dilutes the insecticide that it has no effect on the caterpillars. It is possible that other methods of application of some of the 12 insecticides tested might prove at least partially effective in control, but application by overhead irrigation gave no indication that any insecticide had value when it was applied to a different plot of cane in the following year.

SUMMARY

The use of the overhead-irrigation system established at Colonia Juana Díaz, near Central Cortada, Santa Isabel, P. R., makes possible the application of fertilizers dissolved in water, and of insecticides for the control of soil-insect pests. Experiments were conducted during the crop years 1950 and 1951, using the overhead-irrigation system as a means of applying insecticides, in an attempt to control the sugarcane moth-stalk borer, *Diatraea saccharalis* (Fabricius).

Thirteen different kinds of insecticides, namely: Aldrin, Chlordane, Dieldrin, Ryania, Rhothane (DDD), Benzene hexachloride, CPR Emulsion Concentrate, Gy-phene (Toxaphene), Marlate (Methoxychlor), Kryocide (natural cryolite insecticide), Dilan 25 EM, Heptachlor 2E Emulsion Concentrate, and Dr. Wolf's Insecticide A, were used. Each insecticide was applied at two different concentrations. Thirty-one plots planted with sugarcane, each having an area of 2½ acres, were used in the experiment, 20 of them being treated with insecticides and 11 being used as checks.

The insecticides were applied at 15-day intervals; there were four sprayings during each season. The experiments were initiated during the fall of 1950 and 1951, respectively, when the sugarcane plants were still small and had just begun to develop the first joints at the base of the stalks.

The tables and analyses of the work conducted demonstrated that these insecticides, at least when applied by this method of spraying, were completely ineffective in the control of the insect. In many cases the check plots showed less borer infestation than those treated with insecticides; in others, the insecticide was more effective at low concentration than when used at twice that concentration.

The ineffectiveness of the insecticides might be due, in part, to the large amount of water used which reduced the concentration of the chemical so much as to make it valueless in controlling the moth-borer.

RESUMEN

El uso del sistema de riego artificial aéreo establecido en la Colonia Juana Díaz, cerca de la Central Cortada, Santa Isabel, P. R., hace posible la aplicación de los abonos disueltos en agua y de los insecticidas para la represión de los insectos que viven en el terreno. Para combatir el taladrador del tallo de la caña, *Diatraea saccharalis* (Fabricius) se iniciaron dos experimentos durante los años 1950 y 1951, en los cuales se usó este método de dispersión de los insecticidas.

Se usaron 13 clases de insecticidas, a saber: Aldrín, Clordano, Dieldrín, Ryania, Rotano, Hexaloruro de benceno, Emulsión concentrada CPR, Gyphene, Marlate, Kryocide, Dilan, Heptachlor e Insecticida Dr. Wolf. Cada uno de estos insecticidas se aplicó en dos concentraciones distintas. Ambos experimentos incluyeron 31 parcelas sembradas de caña, 20 de éllas tratadas con insecticidas y 11 testigos. Los insecticidas se aplicaron a intervalos de 15 días, esto es 4 aspersiones durante la temporada. Los experimentos se llevaron a cabo durante las temporadas de otoño de 1950 y 1951, respectivamente, cuando la caña estaba aún pequeña y empezaba a formar canutos en la base de los tallos.

Las tablas y un análisis del trabajo efectuado, demuestran que estos insecticidas, por lo menos cuando se usó el método de riego artificial aéreo, fueron completamente ineficaces para controlar el insecto. En muchos casos la infestación en las parcelas testigos fué menor que en aquellas a las cuales se les aplicaron insecticidas; en otros casos los insecticidas de concentraciones bajas resultaron más eficaces para el combate del insecto que los mismos usados en concentraciones más altas.

Es muy posible que la ineficacia de los insecticidas fuese motivada, en parte, por la gran cantidad de agua que se usó en su dispersión. No hay duda sobre que ésto redujo la concentración del insecticida hasta hacerlo completamente ineficaz para controlar el taladrador del tallo de la caña.

INFLUENCE OF ROOT-KNOT NEMATODES ON THE DECLINE IN VIGOR OF THE RED SPANISH VARIETY OF PINEAPPLE IN PUERTO RICO

L. A. Alvarez-García and Lidy López-Matos[1]

INTRODUCTION

Pineapple growers in Puerto Rico have been quite preoccupied with the loss of vigor and low yields of the Red Spanish variety of pineapples. They have claimed that the loss in vigor indicates a degeneration taking place in this variety when grown for two or more generations in our agricultural environment.

The correctness of this statement perhaps can be accepted in terms of the relation between detrimental biological-parasitic and physicochemical factors responsible in some way for the reduction in yield of pineapples, but probably not in terms of the intrinsic loss of yield potentialities because of modifications of the germ plasm. The second statement seems to have the support of the results of recent investigations carried out at the Agricultural Experiment Station of the University of Puerto Rico, where the loss in vigor of pineapple plants has been associated with unfavorable conditions in the growth medium (1, 2, 3, 4, 5, 6, 7, 8).[2] These investigations have shown that filter-press cake incorporated into the soil and the application of fertilizer containing potassium, phosphorus, and nitrogen (as ammonium sulfate) are beneficial to the development of pineapple plants.

The problem has so far been investigated strictly from a physicochemical standpoint. The relation of biological-parasitic factors has not been considered in previous studies. This circumstance led us to initiate field experiments for the purpose of determining the relation of root nematodes to the decline or loss in vigor of the Red Spanish variety of pineapples in Puerto Rico. The experiments were started during the period 1951–53 in a Bayamón clay loam, a good pineapple soil, at Arecibo.

The first experiment was planted on October 18, 1951.

EXPERIMENTAL METHODS

Field Procedure

Pineapple slips of the Red Spanish variety were selected for uniformity in size and were planted in two rows in the center of beds 4 feet and 6

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[2] Numbers in parentheses refer to Literature Cited, p. 72.

inches wide by 15 feet long. The slips were spaced 18 inches between rows and 15 inches between plants. The usual commercial procedure for preparing, planting, and cultivating the land were followed.

The layout of each experiment was that of a randomized split-plot arrangement, consisting of six soil treatments, each treatment replicated six times, and five spray treatments per soil treatment.

Nematocides[3] used for soil treatment were:

1. Dowfume G (methyl bromide, carbon tetrachloride, and ethylene dichloride); methyl bromide, 10 percent by volume, at the rate of 6 cc. per square foot of soil.
2. DD (dichloropropane and dichloropropene) 50 percent per volume, at the rate of 6 cc. per square foot.
3. Dowfume W 85 (ethylene dibromide) 40 percent per volume, at the rate of 6 cc. per square foot.
4. Dowfume N (dichloropropane and dichloropropene) 50 percent per volume, at the rate of 6 cc. per square foot.
5. Dowfume W 40 (ethylene dibromide) 20 percent per volume, at the rate of 9 cc. per square foot.
6. Check, no chemical applied.

The chemicals were injected into the soil at a depth of 6 inches with a Spielden hand injector. All soil treatments were given 15 days before planting.

All plots were sprayed with Aldrex at the rate of 1 gallon per acre of the 25-percent emulsion (2 pounds of Aldrin), diluted in 100 gallons of water, 6 days before planting, to control ants and white grubs.

The planted slips were sprayed with Resitox (2 pounds in 100 gallons of water) containing DDT, and Aldrex to control mealybugs and ants. The Resitox-Aldrex emulsion was sprayed monthly all over the field until July 26, 1952, when Parathion (15 percent) at the rate of 1 pound in 100 gallons of water, was used to control mealybugs. Parathion sprays were discontinued immediately after the pineapple plants began flowering.

The following materials were sprayed on the plants monthly to test their relative effectiveness on the control of *Thielaviopsis* (*Ceratostomella*) *paradoxa* leaf spot, chlorosis, and fruit rot, respectively:

1. Iron sulfate, 25 pounds per acre in 100 gallons of water.
2. Fermate (ferric dimethyl dithiocarbamate), 2 pounds per acre in 100 gallons of water.
3. Dithane Z-78 (zinc ethylene bisdithiocarbamate), 2 pounds per acre in 100 gallons of water.
4. Zerlate (zinc dimethyl dithiocarbamate), 2 pounds per acre in 100 gallons of water.
5. Check (water only).

[3] Chemicals were supplied free by the Dow Chemical Co.

The experiment was conducted in Enrique Landrón's pineapple farm, at Palo Blanco, Arecibo. The soil there is a friable Bayamón silty clay which has been cropped with pineapples for about 20 years. It has a pH of 4.80, and thus is adequate for pineapple-growing, although at the time this work started it was producing very low yields.

Previous examination of the roots from pineapple plants grown in this field showed heavy infestation with nematodes.

Harvesting

The pineapple plants started flowering by January 1953. The fruit was harvested during May and June of the same year. The experimental data recorded were: Number and size of fruits per plot, total weight of the fruit for every soil and spray treatment, and number of slips and suckers produced. As no acetylene treatment was given, only two-thirds of the plants flowered.

EXPERIMENTAL RESULTS AND STATISTICAL INTERPRETATION

Effect of the Soil Treatment on Plant Growth and Fruit Yields

Marked differences in rate of growth were observed among the plants in the plots treated with nematocides and in the plots not fumigated. The plants in the treated plots were greener, stockier, and more vigorous. Those in the check plots were small and to some extent chlorotic.

Plants growing on plots treated with Dowfume W-85 were greener and developed more vigorously.

The effects of the soil treatments on the yield of fruit are shown in table 1. They indicate that, at the 5-percent statistical level, Dowfume W-85 and Dowfume W-40 were superior to Dowfume G and Dowfume N in control-

TABLE 1.—*Effect of different soil treatments on the yield of marketable Red Spanish pineapple fruits grown in Bayamón silty-clay loam at Palo Blanco, Arecibo, P. R.*

Soil treatment	Yield per acre
	Tons
Dowfume G	10.78
DD	13.13
Dowfume W-85	15.92
Dowfume N	12.32
Dowfume W-40	14.87
Check	6.24

L.S.D.: At the 5-percent point = 2.49 tons per acre; at the 1-percent point = 3.39 tons per acre.

TABLE 2.—*Statistical analysis of the effect of different spray treatments on the yield of pineapples*

Spray treatment	Yield per acre
	Tons
Iron sulfate	12.53
Fermate	11.30
Dithane Z-78	11.64
Zerlate	12.34
Check	13.25

L.S.D.: At the 5-percent point = 1.65 tons per acre; at the 1-percent point = 2.26 tons per acre.

ling nematodes. At the 1-percent level, Dowfume W-85 and Dowfume W-40 were superior to Dowfume G.

All soil treatments were significantly superior to the Check, at both the 5-percent and 1-percent levels. In regard to increase in tonnage, the superiority over the Check ranged from 4.54 tons to 9.68 tons per acre, which is equivalent to a production ranging from 70 percent to 200 percent over the Check. This represented a substantial increase in income per acre.

Effect of Spray Treatments on the Yields

The statistical analysis of the yields of plots sprayed with iron sulfate, Fermate, Dithane Z-78, and Zerlate, is presented in table 2. The data show that there were no significant differences at the 1-percent level between the yields of plants sprayed with the different chemicals. At the 5-percent level, the Check was superior to Fermate. Apparently, this chemical had a depressive effect on the yield.

Only a few scattered and insignificant leaf lesions caused by the fungus *Thielaviopsis* (*Ceratostomella*) *paradoxa*, appeared during the growing period.

The fruit in all treatments was free from blemishes and infections. Probably the treatment with DDT and Parathion reduced the fruit injuries from insect attack to a minimum. Fruit injuries are usually associated with secondary infections by saprophytic fungi, which reduce the market quality of the fruits. Insect injuries may also provoke gummosis, but in this experiment the fruit harvested was free of gum.

Table 3 shows that all the spray treatments plus the soil treatments had an effect on the yield superior to the Check, though there were no significant differences between the yields under sprays with the same chemical soil treatment but there were significant differences between soil treatments with the same spray. The rank in descending order was Dowfume W-85,

TABLE 3.—*Effect of different soil and spray treatments combined on the yield of pineapples.*

Spray treatment	Yields per acre for soil treatment indicated—					
	Dowfume G	DD	Dowfume W-85	Dowfume N	Dowfume W-40	Check
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Iron sulfate	10.45	13.77	17.92	12.46	14.60	6.00
Fermate	10.59	12.55	15.44	9.51	12.93	6.77
Dithane Z-78	9.75	13.04	14.77	12.49	14.45	5.36
Zerlate	12.73	11.68	15.90	12.68	15.84	5.19
Check	10.37	14.64	15.58	14.48	16.53	7.88

L.S.D. between the means of spray treatments within each soil treatment: At the 5-percent level = 3.52 tons per acre; at the 1-percent level = 4.67 tons per acre.
L.S.D. between the means of soil treatments with the same spray treatment: At the 5-percent level = 3.83 tons per acre; at the 1-percent level = 5.12 tons per acre.

Dowfume W-40, DD, Dowfume N, Dowfume G, and Check, alone or combined with the spray treatments.

It seems preferable to use the iron sulfate sprays in alkaline soils to prevent chlorosis. The treatments with Dowfume W-85 and iron sulfate produced yields of approximately 18 tons per acre, which is three times that (6 tons per acre) obtained in the check plots.

Effect of Soil Treatments on the Number of Slips Produced per Acre

The data obtained on the mean number of slips produced by Red Spanish pineapple plants grown in plots treated with the various soil fumigants, respectively, are presented in table 4.

According to the above analysis, at the 1-percent level the mean number of slips produced by pineapple plants grown in plots treated with Dowfume

TABLE 4.—*Effect of different soil treatments on slip production by pineapple plants*

Soil treatment	Number of slips per acre
Dowfume G	22,974
DD	36,719
Dowfume W-85	47,432
Dowfume N	32,028
Dowfume W-40	45,386
Check	11,939

L.S.D.: At the 5-percent point = 10,223 slips per acre; at the 1-percent point = 13,943 slips per acre.

TABLE 5.—*Statistical analysis of the effect of different spray treatments on slip production by pineapple plants*

Spray treatment	Number of slips per acre
Iron sulfate	32,215
Fermate	34,577
Dithane Z-78	27,588
Zerlate	33,770
Check	35,584

L.S.D.: At the 5-percent level = 7,657 per acre; at the 1-percent level = 10,444 per acre.

W-85 was significantly greater than the mean number of slips produced by plants in soil treated with Dowfume N, Dowfume G and the Check; Dowfume W-40 was superior to Dowfume G and the Check; and DD was superior to the Check. At the 5-percent level, all the treatments were significantly superior to the Check. A comparison among the chemical treatments showed that Dowfume W-85 was superior to DD, DD to Dowfume G, and Dowfume W-40 to Dowfume N.

Effect of Spray Treatments on the Mean Number of Slips Produced

The statistical analysis of the mean number of slips produced by pineapple plants sprayed with different chemicals is shown in table 5. There was no significant difference between the different sprays at the 1-percent level but at the 5-percent level the Check was superior to all the chemical spray treatments. This indicates that under the experimental conditions,

TABLE 6.—*Effect of different soil and spray treatments combined on the mean number of slips produced by pineapple plants*

Spray treatment	Results of using indicated soil treatment —					Check
	Dowfume G	DD	Dowfume W-85	Dowfume N	Dowfume W-40	
Iron sulfate	19,683	34,682	52,059	29,363	45,819	12,048
Fermate	26,568	41,837	54,853	24,523	45,173	14,520
Dithane Z-78	18,605	31,408	40,546	30,221	36,029	8,712
Zerlate	26,026	34,842	44,960	37,642	49,478	9,680
Check	23,987	41,192	44,741	38,397	50,446	14,733

L.S.D. between two soil-treatment means for the same spray treatment: At the 5-percent level = 14,762 slips per acre; at the 1-percent level = 19,770 slips per acre.
L.S.D. between two spray-treatment means for the soil treatment: At the 5-percent level = 13,998 slips per acre; at the 1-percent level = 18,725 slips per acre.

the chemical sprays were not essential and were even somewhat depressive to the vigor of the pineapple plants.

Effect of Soil and Spray Treatments on Slip Production

Table 6 shows the mean number of slips of pineapple plants under different soil and spray treatments. The data show that there was no significant difference between the spray treatments within each soil treatment or among all soil treatments. Dowfume W-85 and Dowfume W-40 were superior to the others, followed by DD and Dowfume N.

The results on the mean number of suckers produced by pineapple plants undergoing the different soil treatments are presented in table 7. At the 1-percent level, all treatments were superior to the Check, but Dowfume W-85 and Dowfume W-40 were superior to Dowfume G. At the 5-percent level, Dowfume W-85 and Dowfume W-40 were superior to Dowfume N.

In table 8 it can be seen that there were no significant differences between the effects of different spray treatments on sucker production. The number of suckers fluctuated between 9,448 and 10,758.

The combined effect of soil and spray treatments on sucker production

TABLE 7.—*Effect of different soil treatments on sucker production by pineapple plants*

Soil treatment	Number of suckers per acre
Dowfume G	9,357
DD	11,055
Dowfume W-85	13,339
Dowfume N	10,371
Dowfume W-40	12,823
Check	4,517

L.S.D.: At the 5-percent level = 2,316 suckers per acre; at the 1-percent level = 3,159 suckers per acre.

TABLE 8.—*Effect of different spray treatments on sucker production by pineapple plants*

Spray treatment	Number of suckers per acre
Iron sulfate	10,687
Fermate	9,448
Dithane Z-78	9,669
Zerlate	10,629
Check	10,758

L.S.D.: At the 5-percent level = 2,316 suckers per acre; at the 1-percent level = 3,159 suckers per acre.

TABLE 9.—*Effect of different soil and spray treatments combined on sucker production per acre by pineapple plants*

Spray treatment	Results of using indicated soil treatment—					Check
	Dowfume G	DD	Dowfume W-85	Dowfume N	Dowfume W-40	
Iron sulfate	9,680	11,726	15,701	9,790	12,907	4,304
Fermate	9,467	11,184	13,016	7,208	11,080	4,730
Dithane Z-78	7,744	10,971	12,694	10,435	12,048	4,304
Zerlate	10,971	9,467	13,661	11,726	14,197	3,762
Check	8,925	11,939	11,616	12,694	13,875	5,485

L.S.D. between two spray-treatment means for the same soil treatment: At the 5-percent level = 3,704 suckers per acre; at the 1-percent level = 4,953 suckers per acre.

L.S.D. between two soil-treatment means for the same spray treatment: At the 5-percent level = 3,588 suckers per acre; at the 1-percent level = 4,787 suckers per acre.

is shown in table 9. These data indicate that there were no significant differences due to spray treatments when used with the same soil treatment, but that there were significant differences due to soil treatments when used with the same spray treatment.

Effect of Soil Treatments on Size of Fruits

Table 10 shows the effect of the different soil treatments on size of fruit. According to this table the percentages of fruits of the size numbers varied with the different soil treatments, but more larger size fruits were obtained from the plots to which nematocides were applied.

TABLE 10.—*Effect of different soil treatments on size of pineapple fruits produced*

Soil treatment	Percentage of fruits produced of size Nos. indicated														Total	Percent
	16	Percent	18	Percent	24	Percent	30	Percent	36	Percent	42	Percent	48	Percent		
D.[1] G.			22	0.2	968	8.6	2,732	24.3	2,796	24.9	2,732	24.3	2,001	17.7	11,251	100
DD			172	1.4	1,656	13.7	3,657	30.2	2,818	23.3	2,495	20.6	1,312	10.8	12,110	100
D.[1] W-85	22	0.2	301	2.2	2,904	21.6	4,109	30.5	2,947	21.9	2,237	16.6	946	7.0	13,466	100
D.[1] N	22	.2	194	1.7	1,420	12.2	3,248	28.0	2,753	23.7	2,538	21.8	1,441	12.4	11,616	100
D.[1] W-40	43	.3	279	2.1	2,087	15.7	4,109	31.0	3,012	22.7	2,452	18.5	1,291	9.7	13,273	100
Check			22	1.3	387	5.1	1,226	16.2	1,420	18.8	2,065	27.3	2,431	32.3	7,551	100

[1] Dowfume.

DISCUSSION

The results obtained from an experiment with pineapples at Palo Blanco, Arecibo, in Bayamón sandy-loam, demonstrated the beneficial effects of applying fumigants to the soil used for pineapple production.

Pineapple plants grown in plots heavily infested with nematodes produced a mean yield of 6.24 tons of marketable fruits per acre, while those grown in plots treated with fumigants produced higher yields. With the most effective fumigant (Dowfume W-85), a yield of 15.92 tons of pineapples per acre was obtained. The mean increase in yield for all spray treatments was 9.68 tons per acre.

The spray treatments with chemicals containing iron and zinc in organic forms (Fermate, Dithane Z-78, and Zerlate) did not prove superior to iron sulfate sprays. There was no significant difference among the sprays in terms of yield of fruit per acre, at the 1-percent level. However, the Check was superior to Fermate and Dithane Z-78 at the 5-percent level. This seems to indicate a depressive effect of these two chemicals on the plants.

The soil treatments with nematocides increased the production of slips and suckers. According to the data obtained all the pineapple plants in fumigated soil produced significant increases in yield of fruit per acre, in comparison with the Checks. The different soil fumigants also significantly increased the production of slips and suckers.

More larger size fruits were obtained in the plots where nematocides were applied. This is important because larger fruits are sold in the mainland at a higher price.

An Aldrin spray was applied to the soil to control insect pests—especially fire ants (*Solenopsis geminata*) which nurse the mealybugs, and also the white grubs of May bettles (*Phyllophaga spp.*) and the snout beetles (*Diaprepes spp.*) which cause damages to the roots and stems of pineapple plants. Resitox (oil plus DDT) and Parathion efficiently controlled mealybugs, scale insects, aphids, and caterpillars. The importance of controlling these insect pests should not be underestimated. Mealybugs are generally responsible for the mealybug wilt of pineapples, a disease which severely affects the Smooth Cayenne variety. The Red Spanish variety is tolerant, but the mealybugs lower the vitality of the plant and thus the yield per acre is reduced.

This experiment has demonstrated that pineapple cultivation in Puerto Rico can be greatly improved by using soil fumigants.

Yields would probably have been higher if the pineapple plants had been treated with acetylene as is done commercially, but even so the results obtained were practicable. The yield of 18 tons per acre is normal for three-fourths of the crop. It should have been possible to obtain around 24 tons per acre if the plants had been treated with acetylene.

CONCLUSIONS

1. The results of the pineapple experiment conducted at Palo Blanco, Arecibo, during the 1951–53 growing period in a Bayamón sandy-loam soil indicate the importance of controlling root-knot nematodes in pineapple production. The parasites were responsible for the low yields of fruits (6.24 tons per acre), as compared with the fruit produced in the Checks.

2. Fumigation of the soil with Dowfume G, DD, Dowfume W-85, Dowfume N, and Dowfume W-40, was beneficial to the development of the pineapple plants, increasing the yield from 6 to 10 tons per acre, and also producing more fruits of the larger sizes.

3. Dowfume W-85 proved best of all the soil treatments tested. The yield obtained when it was used in combination with the spraying of iron sulfate was up to 18 tons per acre.

4. The so-called degeneration of the Red Spanish variety in Puerto Rico seems to be a loss of vigor due to damage caused by insect and nematode parasites and to improper physicochemical conditions of the soil.

5. The number of suckers and slips produced by soil-treated plants was from two to four times higher, respectively, than the number obtained in the Checks, and the size and vigor of the planting material was far superior to that of the Checks.

6. Pineapple plants grown in soil free from nematodes, white grubs, and mealybugs developed healthy suckers and slips, thus excellent propagating material can be produced in Puerto Rico. It seems, unnecessary, therefore to import Cuban planting material to procure propagating material of high quality.

SUMMARY

1. Pineapple plants planted in nematocide-treated soil, showed greener, stockier, and more vigorous growth than those growing in plots not so treated. The mean yield obtained from pineapple plants cultivated on the nematocide-treated soil was from 10.78 to 15.92 tons of fruit per acre. The Checks produced a mean yield of 6.24 tons per acre.

2. The results of the soil treatments indicated that Dowfume W-85 was superior to all other nematocides, irrespective of spray treatments. The Dowfume W-85 soil treatment combined with iron sulfate sprays produced the heaviest yields, 17.92 tons per acre.

3. The mean number of slips produced per acre obtained with the different soil treatments varied from 22,974 to 47,432, in contrast with 11,939 produced in the Check plots. The highest yield of 47,432 slips per acre corresponds to treatment with Dowfume W-85.

4. The mean number of suckers produced per acre, obtained with the nematocide-treated plots ranged from 9,357 to 13,339, in contrast with a

mean yield of 4,517 produced in the Check plots. Dowfume W-85 was best with a mean yield of 13,337 suckers per acre. This treatment produced 15,701 suckers per acre when combined with iron sulfate sprays, and the percentage of larger fruits (sizes 12 to 36) was 74 (see table 9) as compared with the Check at 40.

5. The percentage of large fruits was higher in all plots treated with nematocides.

RESUMEN

1. Se realizó un ensayo en un terreno del tipo Bayamón lómico-arenoso en la finca del Sr. Enrique Landrón en el barrio Palo Blanco de Arecibo, para probar la eficacia de varios nematocidas.

Se seleccionó un sito infestado con nemátodos (*Meloidogyne*) los cuales causan hernias en las raíces de las piñas. Se probaron los siguientes nematocidas: Dowfume G, DD, Dowfume W-85, Dowfume N y Dowfume W-40.

2. Los aumentos en los rendimientos donde se aplicaron los nematocidas fluctuaron entre 10 y 16 toneladas por acre, en contraste con la producción de los testigos, que solamente produjeron un promedio de 6 toneladas por acre. El mejor fumigante fué el Dowfume W-85, cuya aplicación hizo aumentar el tamaño de las frutas y la producción hasta 18 toneladas por acre, cuando se acompañó el tratamiento con las aspersiones de sulfato de hierro. Esto constituye un aumento de 12 toneladas por acre sobre los testigos.

3. Para eliminar otros factores biológicos adversos se asperjaron las piñas mensualmente con Resitox (emulsión de aceite con DDT) durante los primeros meses de crecimiento y luego se usó el Parathion.

4. Para erradicar las hormigas bravas, que son nodrizas y distribuidoras de las cochinillas en los plantíos, y también eliminar los gusanos blancos de caculos y vaquitas (coleópteros) se incorporó Aldrín al terreno antes de la siembra. El Aldrín también se usó conjuntamente con el Resitox y con el Parathion para asperjar las plantas de piña.

5. En las parcelas fumigadas se aumentó considerablemente la producción de material para la propagación. Se obtuvieron aproximadamente 50,000 "slips" en comparación con sólo 12,000 en los testigos, y 13,000 "suckers" contra 4,000.

6. La "semilla" o material de propagación producida por las plantas sembradas en terreno fumigado y asperjado con Resitox-Algrin y Parathion, no sólo fué mayor, sí que también fué de calidad comparable con la mejor que se importa de Cuba.

Podemos concluir que el uso de fumigantes e insecticidas en el cultivo de la piña hace innecesaria la importancia de semilla de otros países y que la producción de frutas se puede aumentar por lo menos a 18 toneladas

por acre. Este aumento significa el doble de la producción promedio actual en Puerto Rico.

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